Engineering Library

SEP 8 1931

MAINTENANCE ENGINEERING

IN PLANTS, MILLS, AND FACTORIES

FORMERLY 'INDUSTRIAL ENGINEERING'

IT CAN BE DONE—A One-Act Prosperity Play

Maintenance Engineer: I do wish business would pick up!

Straight-Thinking Friend: What an original thought! And what are you doing about it, beside wishing?

M.E.: Nothing. How can I? What can I do?

S.T.F.: Sell something. Industrial plants need orders. Orders beget orders. An abundance of orders creates confidence. Confidence means renewed business activity—just what you want.

M.E.: Me sell? We have a sales force for that job. Why, I couldn't earn carfare at selling.

S.T.F.: Wouldn't expect you to. Want you to sell for nothing, and not your own products, either.

M.E.: Explain yourself.

S.T.F.: All I want you to do is to sell equipment in your own plant.

M.E.: Whose equipment?

S.T.F.: Don't care. Pick out the best for the work it must do.

M.E.: And who will buy it?

S.T.F.: Whoever won't buy now — the purse-string puller in your plant.

M.E.: I get your drift. But suppose we don't need equipment?

S.T.F.: You do, though. Every plant needs something.

M.E.: Yes, we do, that's a fact. But if regular salesmen can't sell equipment here, how can I?

S.T.F.: Boy, you're a better salesman right now than any of them—in your own plant. You can show how modern equipment will reduce the unit cost of what your company makes.

M.E.: I see. And the lower the cost of production the greater the net profit.

S.T.F.: Right. And the greater the net profit the greater the competitive ability.

M.E.: The result will be more orders for our plant.

S.T.F.: You have the idea. Will you do it?

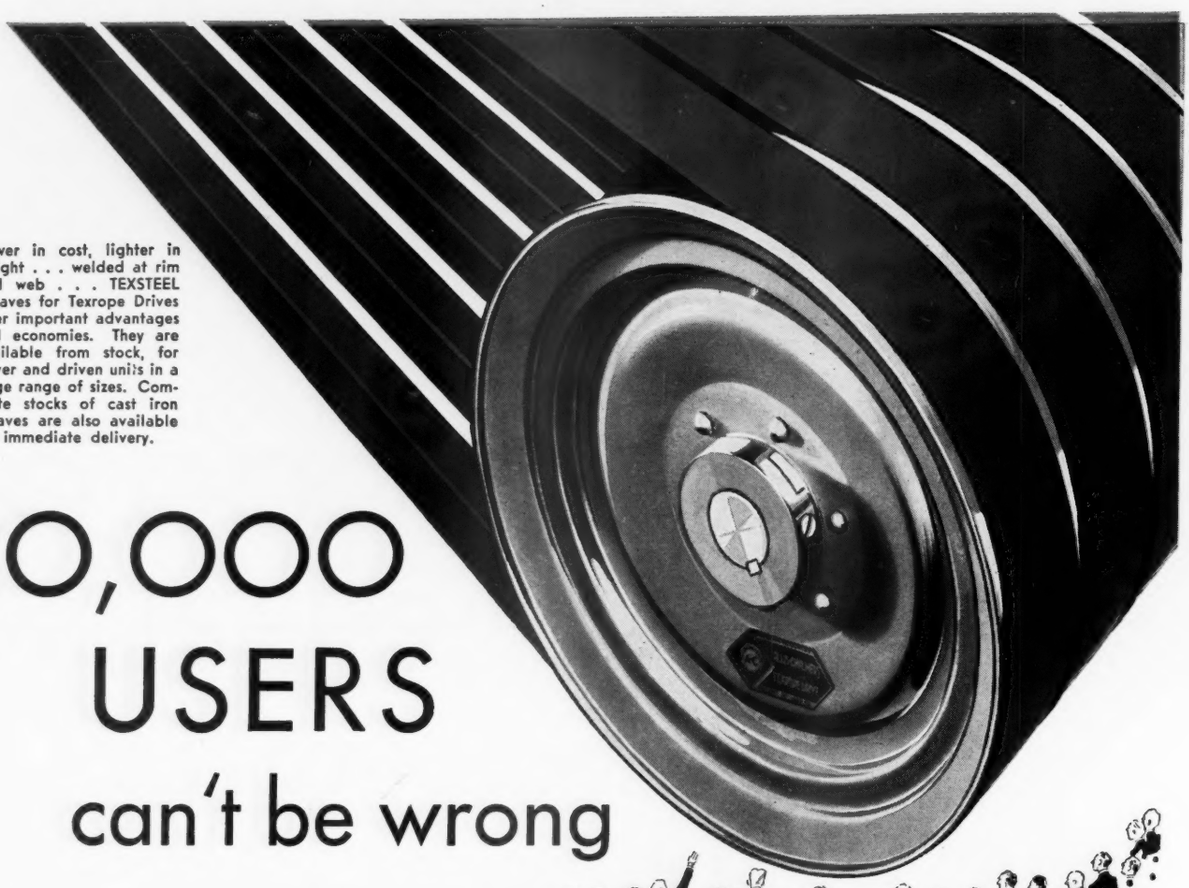
M.E.: Will I? Gangway!

A McGraw-Hill Publication

25 cents a copy

SEPTEMBER

1931



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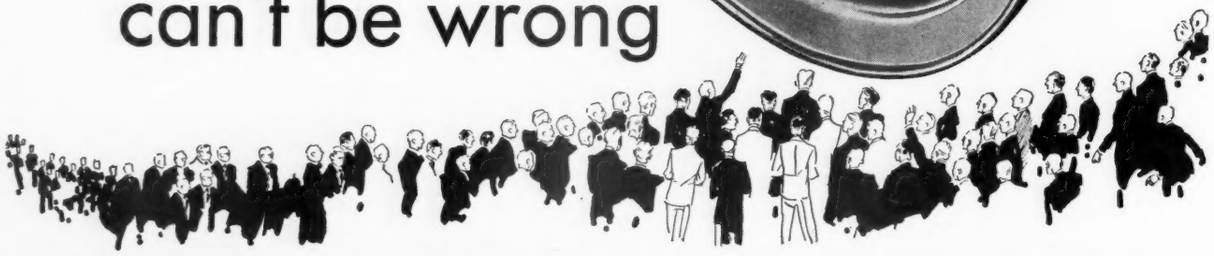

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Some 20,000 users can't be wrong . . . and over 100,000 Texrope Drives in satisfactory service indicate the outstanding success of this Allis-Chalmers product.

May we remind you that the Texrope Drive, originated by Allis-Chalmers, is the original multiple V-belt drive. More than two years of testing and experimenting preceded its announcement some six years ago. Tested at Carnegie Institute, Texrope Drives proved to be 98.9% efficient . . . and this efficiency is sustained for the life of the drive.

Tested in actual service, *since 1925, in every branch of industry, on all kinds of machines, under excessive heat and cold, moisture and dust,* Texrope Drives have proved practical.

Surprising savings have been made by users who have installed Texrope Drives. They have proved what only time can tell . . . that they save money for their users and give dependable, continuous service with low cost for maintenance.

Each drive is correctly engineered to assure perfect performance and long belt life. Let an Allis-Chalmers *engineer* help you cut costs with genuine Texrope Drives.

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TEXROPE DRIVES

THE DRIVES THAT REVOLUTIONIZED TRANSMISSION PRACTICE

MAINTENANCE ENGINEERING

A McGraw-Hill Publication, founded 1882

SEPTEMBER, 1931

CAPACITOR SINGLE-PHASE MOTORS

A review of theory and design, and a general statement of the applications, discussing advantages and limitations

L. T. CAMPEY

Industrial Engineering Department
General Electric Company
Schenectady, N. Y.

THE capacitor motor has come into prominence only in the last three or four years. Many may, therefore, not be aware that motors of this type were built and put into service some 30 years ago when Dr. Steinmetz and his associates secured a number of basic patents. These were followed by further patents from time to time. The expense and somewhat unreliable nature of capacitors hindered development for the next two decades, and it was only the improvement in their construction, stimulated by the radio and the increased demand for power-factor improvement, that brought the capacitor motor more and more to the designer's attention.

THEORY

We are all, no doubt, familiar with two-phase induction motors. In order to obtain a simple conception of the single-phase capacitor motor, we may picture a capacitor of suitable proportions inserted in series with one of the phases of a two-phase induction motor and connected as shown in Fig. 1. This results in a form of capacitor motor, although it is usual to change the design somewhat to obtain better characteristics.

The voltage across the auxiliary winding (sometimes called the starting, or capacitor, winding), is the difference between the line voltage and the voltage across the capacitor. It is approximately 90 deg. out of phase with the line voltage at full-load speed. If the voltage across the capacitor were to remain fixed in magnitude and phase relationship to the line voltage at all speeds, the motor would have the same starting torque as a two-phase motor; but this voltage changes considerably as will be explained later.

The actual starting torque available is only 40 to 60 per cent of the full-load torque, so that the type of motor corresponding to Fig. 1 is known as a low-torque capacitor motor. By increasing the capacitor effect at starting, the starting torque may be increased up to 200 to 300 per cent of full-load torque or higher (see Figs. 2 and 3), and the motor is then referred to as a medium- or high-torque capacitor motor.

In order to study the theory of the capacitor motor, let us take as a typical example the low-torque motor pictured in Fig. 1, and assume the ratio of turns in the auxiliary winding to the turns in the main winding to be approximately 1.7:1. The motor operates most quietly and with maximum efficiency when the field strengths of the main and auxiliary

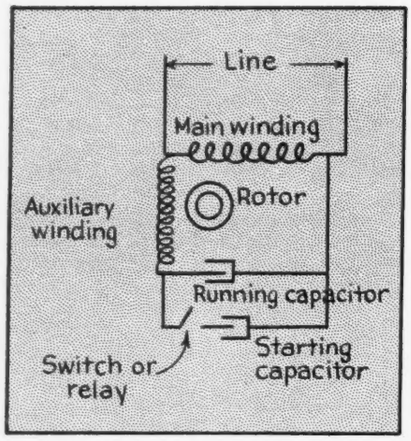


Fig. 1—Low-torque capacitor single-phase motor.

windings are equal and 90 electrical degrees out of phase, or in other words, when the motor has a uniform rotating field. This requires that the ampere turns of each winding be equal. By referring to Fig. 4, it is seen that the current in the auxiliary winding at full-load speed (I_{AR}) when multiplied by the ratio of turns (1.7) is approximately equal to the current (I_{MR}) in the main winding at full-load speed.

In this diagram, as well as in Fig. 5, we shall let

E_L=line voltage,

E_{AS}=voltage on auxiliary winding at start,

E_{AR}=voltage on auxiliary winding at full-load speed,

E_{CS}=voltage on capacitor at start,

E_{CR}=voltage on capacitor at full-load speed,

I_{LS}=line current at start,

I_{LR}=line current at full-load speed,

I_{AS}=current in auxiliary winding and capacitor at start,

I_{AR}=current in auxiliary winding and capacitor at full-load speed,

I_{MS}=current in main winding at start,

I_{MR}=current in main winding at full-load speed,

E_{AH}=voltage in auxiliary winding at start for high-torque connection,

E_{CH}=voltage on capacitor at start for high-torque connection,

I_{AH}=current in auxiliary winding and capacitor at start for high-torque connection, and

I_{LH}=line current at start for high-torque connection.

On the same diagram (Fig. 4), the currents in the main and auxiliary windings at starting are indicated respectively by the vectors I_{MS} and I_{AS}. The capacitative reactance placed in series with the auxiliary winding is of greater numerical value than the latter's impedance, so that the effect of the two in series is that of a capacitative impedance, and hence the current I_{AS} leads the voltage E_L. If the auxiliary winding were a pure inductance, the angle of lead would be 90 deg.; but since it contains some resistance, this angle becomes less than 90 deg. The vector I_{MR} lags the vector

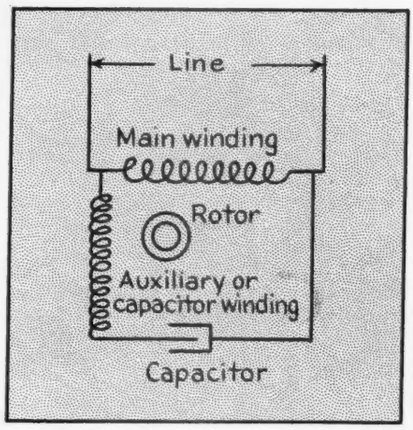


Fig. 2—High-torque capacitor motor (using starting capacitor).

E_L because the main winding is an inductive impedance. The currents in the two windings are out of phase by more than 90 electrical degrees, and produce field strengths in their respective windings whose magnitudes are in the ratio of about 6 or 7 to 1. The voltage across the auxiliary winding at starting is indicated by E_{AS} and leads the current in the winding (I_{AS}). This angle of lead is less than 90 deg. because of the resistance in the auxiliary winding. The voltage across the capacitor is indicated by E_{CS} and lags the current in the capacitor, I_{AS}, by 90 deg. The vector sum of E_{AS} and E_{CS} must equal E_L, the line voltage.

Let us now consider the change in these voltages which takes place as the motor comes up to speed. As in the polyphase induction motor, the apparent impedance of the auxiliary winding increases with increasing speed. The combination of the increasing impedance of the auxiliary winding with the constant capacitative reactance of the capacitor in series with it results in a reduction of their total impedance. This means an increase in current in the auxiliary winding and capacitor with a corresponding increase in voltage on each (although their sum must still equal the line voltage E_L) until the full-load vectors E_{AR} and E_{CR} are reached.

The starting torque of this motor (Fig. 1) is low, and in order to obtain a better value, the capacitative reactance is reduced during the starting period, i.e., the effective kva. of the capacitor is increased. (See Figs. 2 and 3.) This decreases the combined impedance of the capacitor and auxiliary winding, permitting more current to flow and at the same time improving the phase angle between the currents in the main and auxiliary windings, thus producing a much better starting torque. This is shown in Fig. 5, where the reduction in capacitative reactance has increased the current in the auxiliary winding and capacitor from I_{AS} to I_{AH}. The current in the main winding, I_{MS}, is practically unchanged. The voltage on the auxiliary winding is similarly increased from E_{AS} to E_{AH} and as the motor speeds

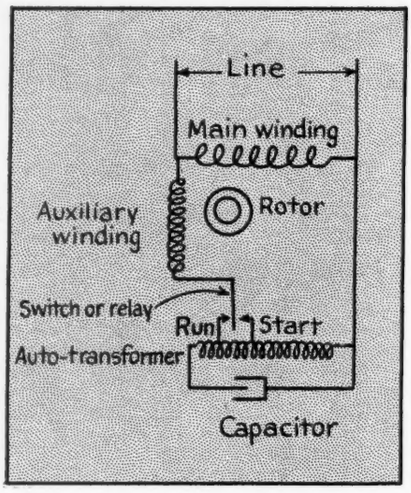


Fig. 3—High-torque capacitor motor (using auto-transformer).

up, this voltage, E_{AH}, and current, I_{AH}, increase in somewhat the same manner as shown for E_{AS} and I_{AS} in Fig. 4. It is necessary, therefore, to increase the capacitative reactance now in order to maintain balanced conditions at full-load speed and to prevent excessive voltages from appearing in the auxiliary winding circuit.

Design and Characteristics

The capacitor motor is essentially a constant-speed low-torque induction motor, but its characteristics may be changed appreciably by varying the resistance of the rotor, the size or the voltage of the capacitor, the relative number of turns in each winding, and so on.

It is usual to design the auxiliary winding with a larger number of

turns than the main winding in order to have a high voltage on the capacitor, thereby permitting the use of a less expensive capacitor. This is not necessarily true if an auto-transformer is used, whereby the voltage applied to the capacitor may be stepped up to the desired value. The rotor has a higher resistance than that of a polyphase motor in order to increase the starting torque to a reasonable value. When a wound rotor and sliprings are used, increased starting torque is obtained. However, this method is rather expensive.

STARTING TORQUE—Figs. 2 and 3 show two common methods of obtaining a high starting torque from the basic low-torque motor shown in Fig. 1. In Fig. 2 an intermittently rated capacitor is inserted in parallel with the running capacitor at starting and is disconnected automatically by a relay at a speed just above that at which the low-torque and the high-torque curves intersect (indicated by point C on Fig. 7). The relay is usually operated by a rise in the voltage on the auxiliary winding as the motor comes up to speed, although a current relay is sometimes used to operate on current rise in the auxiliary winding.

In Fig. 3 the voltage is raised on the running capacitor at starting by means of an auto-transformer. A centrifugal switch mounted on the rotor is usually used to change taps on the auto-transformer at the desired speed (near point A, Fig. 6) thus reducing the voltage on the capacitor. This method is generally adopted for smaller motors, although it is quite practicable to use a centrifugal switch with the arrangement in Fig. 2, or a relay with the arrangement in Fig. 3. The speed-torque curves for a small 1,800-r.p.m. motor are shown in Fig. 6, where the starting torque is increased from approximately 50 per cent to 300 per cent by means of the high-torque connections.

Fig. 5—Vector diagram of low-torque and high-torque capacitor motors at starting.

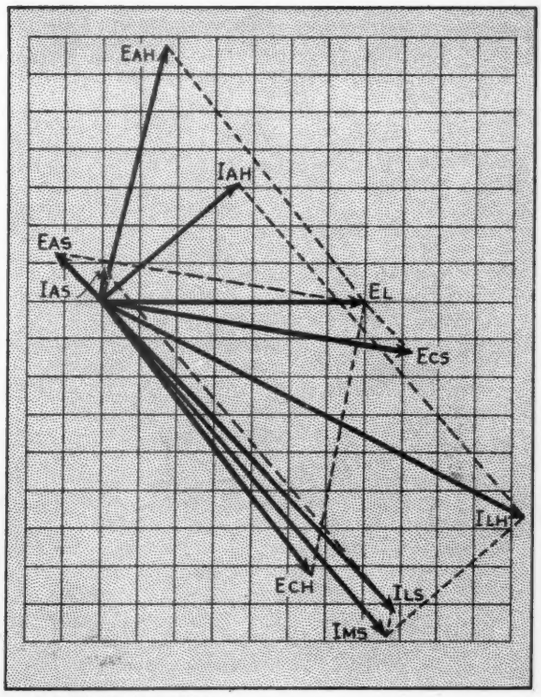
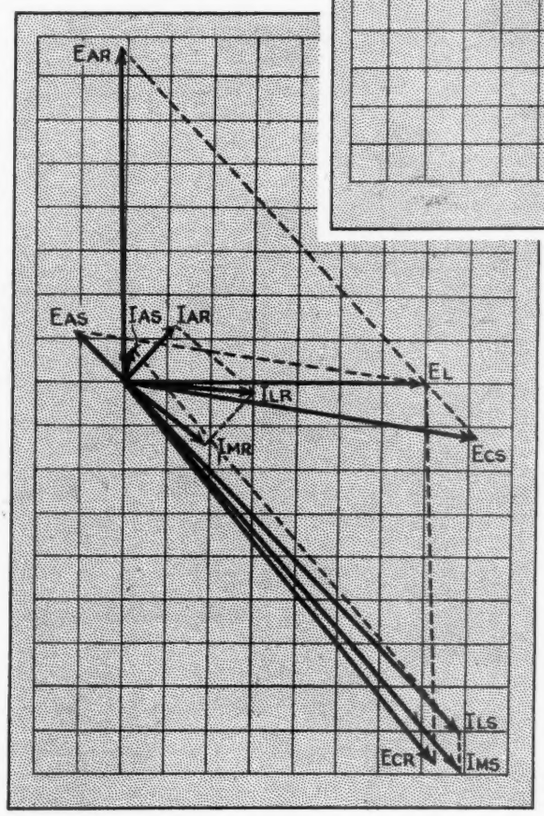
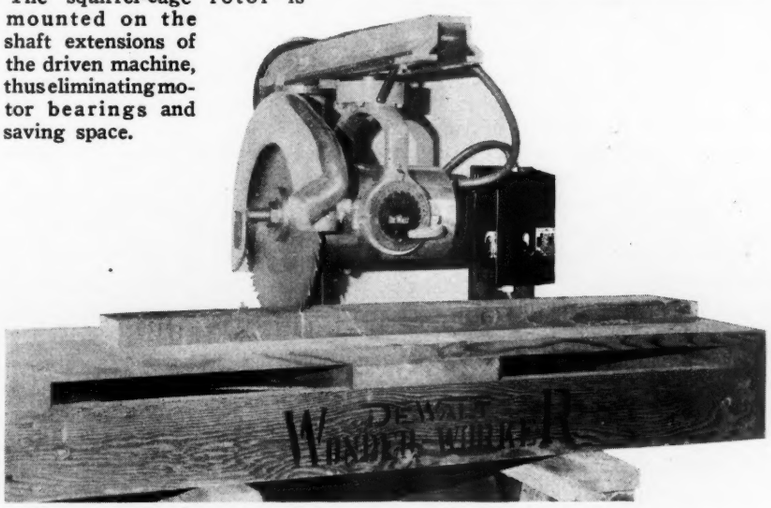


Fig. 4—Vector diagram of low-torque capacitor motor showing starting and running conditions.



The capacitor motor with a squirrel-cage rotor is readily adaptable to built-in applications such as saws, grinders, woodworking machinery, and machine tools in general. The squirrel-cage rotor is mounted on the shaft extensions of the driven machine, thus eliminating motor bearings and saving space.



POWER FACTOR—The power factor of a capacitor motor is inherently high and can be controlled somewhat by the designer, although not without influencing other characteristics. Normal design of the larger motors results in a power factor at full load approaching unity, as indicated in Fig. 6 on the power-factor curve.

EFFICIENCY—The efficiency of a capacitor motor is inherently higher than that of the normal split-phase and repulsion-start induction-run motors chiefly because of the absence of brush and commutator losses, and also because of the reduced copper losses resulting from a high power factor.

DOUBLE-VOLTAGE CONNECTIONS—In the smaller ratings of capacitor motors, it may be desirable to have the motors suitable for connection to either 110 or 220 volts. In general there are three methods of obtaining this result; namely, series-parallel connections, auto-transformer, and extended windings.

The series-parallel connections require that the main and auxiliary windings, as well as the capacitor, consist of two sections which may be connected in series or parallel depending on the voltage available.

The use of the auto-transformer provides a simple method of utilizing either of the voltages by means of high- and low-voltage taps on the transformer; but the additional cost and space required for mounting the transformer are somewhat of a disadvantage in some installations.

The use of extended windings embodies the auto-transformer principle in the motor winding. This method permits the use of a four- or five-lead motor in contrast with the less simple connections of the other two methods, and is being used quite successfully on small double-voltage fan motors.

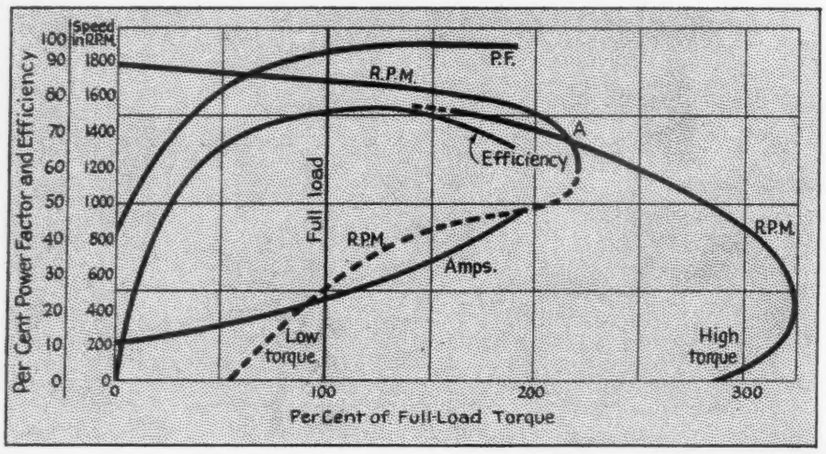


Fig. 6—Characteristic curves of low- and high-torque capacitor motors (See Figs. 1-3).

QUIET OPERATION—Special attention is given in the design of the capacitor motor to the reduction of noise. In the average single-phase induction motor the field is pulsating, and this produces a humming noise, the magnitude of which depends among other things on the flux density in the motor. In the capacitor motor, the auxiliary winding produces a field which at some point around full load has the same strength as the field produced by the main winding, and the combination of these fields results in a uniform rotating field. As the motor becomes overloaded or underloaded, the field gradually loses its uniform character, although in general quite a wide change in load may occur before any appreciable change in noise can be detected.

By suitably designing the motor, the load at which minimum noise occurs may be moved, although for general applications this point is around 80 or 90 per cent of full-load torque. The ratio of slots in the stator and rotor, windage paths, etc., all play an important part in the design of a really quiet motor.

It is advisable here to point out the necessity for caution against using a standard capacitor motor in an application where it may run light part of the time. If a very quiet motor is required, it should be designed especially for that application.

SPEED VARIATIONS—Speed reduction is obtained by reducing the voltage at the motor terminals, for this reduces the starting and maximum torque in proportion to the square of the voltage at the motor terminals. This method of speed reduction is not suitable for constant-torque loads but works out very satisfactorily for fan loads.

A speed reduction of 25 to 30 per cent is readily obtainable with the constant-speed fan motor, although the speed regulation and starting torque on reduced voltages may be improved somewhat if a rotor of very high resistance is used. The speed-torque curves of a variable-speed capacitor motor with a rotor of very high resistance are shown in Fig. 8. The speed-torque curve for a capacitor motor with normal rotor resistance would be similar except that the maximum torque would occur at a higher speed and the starting torque would be somewhat less.

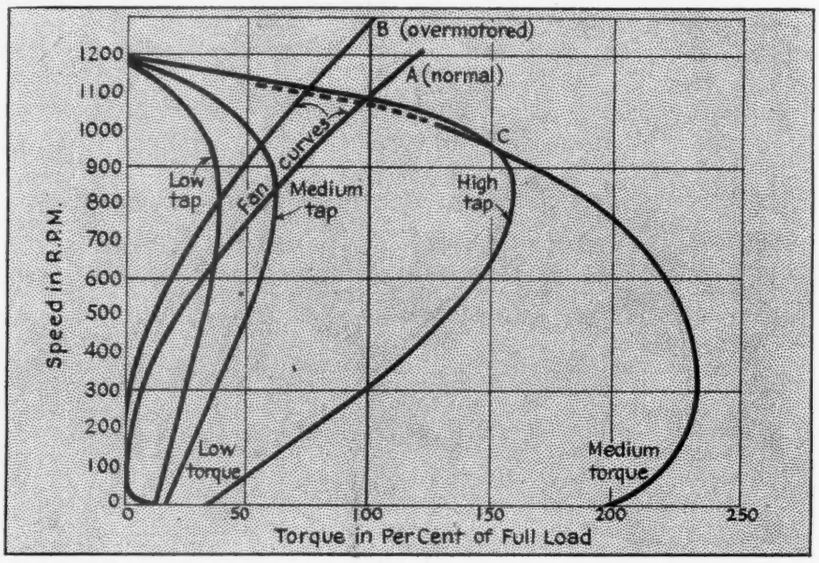


Fig. 7 — Low- and medium-torque capacitor motor curves for variable-speed fan service.

It should be pointed out that to obtain maximum speed reduction, where the motor is for fan drive, the horsepower output of the motor should equal the horsepower requirement of the fan as indicated by curve A, in Fig. 7. When the fan is overmotored, the condition indicated by curve B obtains, and the available speed reduction is diminished. This factor is important, for there is a general tendency to play safe on the size of the motors for fan equipment. This is particularly true for installations connected to extensive duct systems where it is somewhat difficult to

estimate horsepower requirements.

The maximum torque required for fan applications is approximately 125 to 150 per cent of full-load torque, and this is somewhat less than the values shown on Fig. 6. These motors have full-load speeds which are somewhat lower than those of general-purpose polyphase motors, a fact which should be considered when selecting a motor for a given fan.

Constant-speed applications are divided into two broad classes, (a) direct-connected units which use low-torque motors, and (b) belt-driven units which require medium-torque motors. The medium-torque motor is usually derived from the low-torque motor by the addition of a starting capacitor.

Two- and three-speed capacitor motors are now being used to a limited extent for fan applications where the fixed speeds obtainable are satisfactory. There seems to be a potential field for two-speed motors operating at 1,800/1,200, 1,200/900, and 900/720 revolutions per minute.

CONSTRUCTION—One of the major requirements from the mechanical standpoint is that the motors should have interchangeable mounting dimensions with the same rating as other types of single-phase motors so that a capacitor motor may take the place of another type of motor without necessitating any change in the foundations. The capacitor itself is usually mounted in a metal case external to the motor.

Small elevators, hoists, dumb-waiters, and so on, form a very good application for the high-torque capacitor motor. The essential requirements of an elevator motor are (a) high overhauling torque, (b) high starting and accelerating torque, (c) high reversing torque. The complete curves for hoisting and lowering are shown in Fig. 8, and it is seen that each of these conditions is amply taken care of.

If the connections are reversed when the motor is running at full speed in one direction, the motor supplies a reversing torque of approximately 250 per cent of full-load torque, and this value does not fall below 200 per cent throughout the decelerating period. The control must provide an additional contact for putting the starting capacitor back in circuit on reversal, otherwise the high reversing torque will not be obtained.

The capacitor motor with a squirrel-cage rotor is readily adaptable to built-in applications such as saws, grinders, woodworking machinery, and machine tools in general.

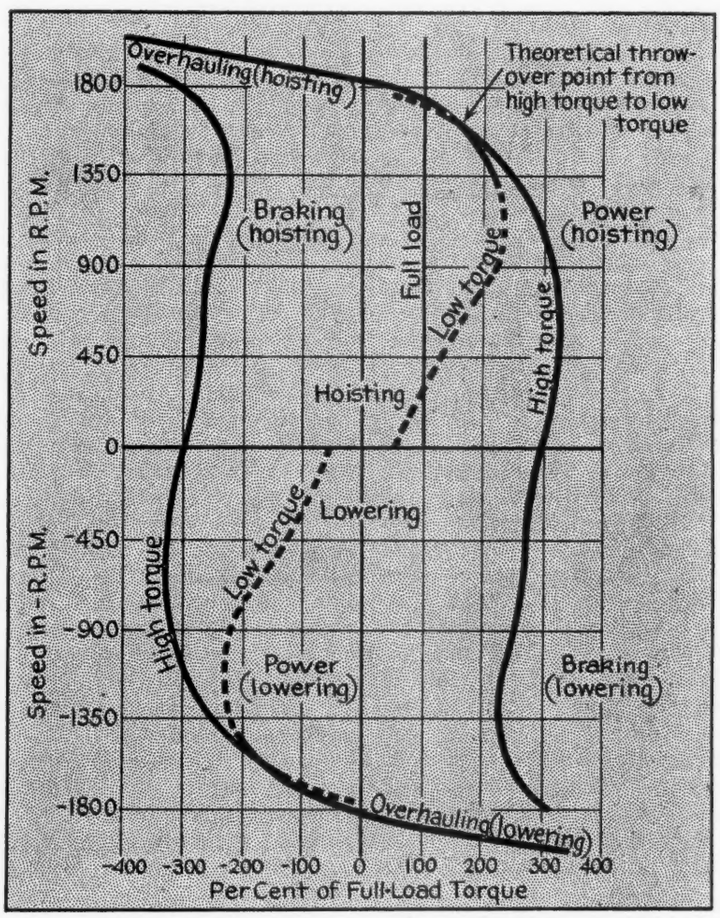


Fig. 8—High-torque capacitor motor curves for elevator service.

CONTROL

The control for capacitor motors is relatively simple and may be divided into the following three general classes according to the application:

(1) Constant-speed, non-reversing.
(2) Constant-speed, reversing.
(3) Adjustable varying-speed, non-reversing.

(1) For a constant-speed, non-reversing motor, a double-pole, full-voltage starting switch is sufficient. A triple-pole, full-voltage starting switch is generally required for the high-torque relay-type motors, the third pole of the switch being used to open the relay-coil circuit.

(2) Constant-speed, reversing motors are practically always high-torque type. To reverse these it is merely necessary to reverse either one of the windings, and at the same time to open the coil circuit of the high-torque relay.

(3) Adjustable varying-speed motors are usually supplied with either an auto-transformer or a resistance controller to reduce the voltage on the motor terminals.

The auto-transformer controller gives inherently better regulation and efficiency and is used quite extensively for controlling the speed of small fan and blower motors.

The resistance controller is less efficient and gives poorer speed regulation than the auto-transformer controller. Regulation, however, is not extremely important on these applications except in the larger sizes. In order to obtain equal decrements of speed, the voltage should be reduced in relatively larger steps at the higher speeds than at the lower speeds.

Provision is often made for starting in the full-voltage position, particularly in the case of low-torque motors with the resistance regulators, because the starting torque available is reduced in proportion to the square of the voltage at the motor terminals.

When high-torque motors are required for variable-speed service an additional provision should be made to insure the opening of the starting-capacitor circuit after the motor has started. One method of doing this is to use a definite time relay which commences to "time-out" after the line switch or contactor is closed.

WATERPROOFING WITH EMULSIFIED ASPHALT

STANLEY C. HUNTER

Maintenance Counselor
The Tremco Manufacturing Company
Cleveland, Ohio

FOR WATERPROOFING and protecting various kinds of surfaces, bituminous materials have been widely used, and possess many important advantages. Among the disadvantages of the ordinary heated or cut-back bituminous compounds, the smoke, fumes, and fire hazard are the most serious, particularly for interior work.

High-grade emulsified asphalt of the proper texture and consistency for waterproofing all types of surfaces is now available. This material, which is tasteless and odorless, can be applied to any surface where the temperature at the time of application remains above 40 deg. F., with no more danger or labor than would attend the use of plain water.

Emulsified asphalt contains water, and so can be used very successfully on damp surfaces. The moisture in the emulsion will migrate into the surface to be waterproofed, carrying the asphalt with it, until the water has been entirely absorbed. This leaves the cells of the surface entirely closed with pure asphalt, from which all water has been removed by evaporation and capillary attraction, and with which water will not mix again. A greater penetration of porous surfaces, such as masonry, results, than occurs when heated materials, or those with a volatile oil content, are used.

When emulsified asphalt is applied to concrete of average porosity it will penetrate to such a depth and seal all surface openings so effectively that water under considerable pressure will not break through, even when applied to the opposite or non-waterproofed side of a concrete wall. To accomplish such results it is necessary to see that the surface to be waterproofed is free from dust, oil, or any other substance that might prevent the water in the emulsion from penetrating the surface. The surface also should be damp, but not waterlogged. There always should be less water in the surface to be waterproofed than there is in the emulsion. The steps to be taken are as follows:

Thoroughly clean the surface to be waterproofed. Dampen with clean water and then apply, with spray or brush, a priming coat of the emulsified asphalt which has been thinned with clean water to the consistency of thin cream. When this has dried tacky, from one to six hours later, apply a second coat as heavy as can be handled in the gun or by brush. A little fresh portland cement with an equal amount of water may be added in the proportion of one part cement to five parts emulsified asphalt, to prevent stickiness if the finished surface is to be left uncovered.

This treatment can be applied to any clean and unpainted surface; it will serve also as a fumeproof and rustproof coating. When used with paper and fabrics as a waterproof membrane in floors, walls, and in the installation of insulation, it is not necessary to use saturated fabrics; because emulsified asphalt is always applied cold, there is no danger of burning the fabric used.

The asphalt used in high-grade emulsified asphalts contains a small amount of a mineral colloid, and will stand much higher temperatures without sagging than will other bitumens.

If the black appearance of emulsified asphalt used as a waterproof or protective coating is objectionable, it may be painted. For exterior work it is recommended that two coats of aluminum paint be applied after the second coat of asphalt has dried well. It may be necessary to wait several days before applying the second coat of aluminum paint because the oil in it has a tendency to soften the surface of the emulsified asphalt, making it dry slowly.

If the painting job is small it may be done with a brush. Care must be taken to avoid too much brushing when applying the first coat. Aluminum paint also may be used on interior surfaces coated with emulsified asphalt, but where an odorless material with a high-gloss white finish is desired, a spirit enamel is recommended. This should be applied in two coats in order to obtain a clean surface that is washable, and will not soil easily.

Concrete grain tanks and similar structures that are not waterproof may be repaired and improved in appearance if the following directions are followed closely:

When the tanks are full, and the weather is warm, all fissures should be examined and defective concrete chipped out.

If the resulting cracks are more than an inch wide and an inch deep, they should be filled with concrete; small openings may be caulked with a mixture of equal parts of emulsified asphalt and asbestos fiber. The opening should be thoroughly dampened and the mixture well forced in place.

The concrete exterior should then be given two coats of emulsified asphalt. While the second coat is drying a piece of 4-oz., single-fill canvas should be thoroughly soaked and stretched out to dry and shrink. Before it is entirely dry it should be given a coat of emulsified asphalt and, while still moist, smoothly put in place around the tank. Start at the bottom of the tank and make each strip of canvas lap the joints about 2 in. Do not pull the canvas too tightly when applying it, so that there will be ample slack to take care of any further shrinkage. The coated side of the canvas should be well pressed into the surface of the emulsified asphalt on the tank.

Another coat of emulsified asphalt should be applied after the canvas is in place; then a coat of aluminum paint may be given. Oil paint, closely resembling concrete in color, may be applied next, and a completely waterproof job of excellent appearance will result.

Maple blocks, laid herringbone in a mastic bond over a concrete base, make a floor that dry-rot cannot touch.

H. S. JACOBY
Chief Engineer
The H. K. Ferguson Company
Cleveland, Ohio

The Factory Floor

Part II (Conclusion)

THE two most popular and satisfactory wood floors are made from regular maple flooring and yellow-pine wood blocks. Deviation from these two general types appears in the cases of yellow-pine flooring and maple wood blocks. It is entirely feasible to reduce the initial cost by using a pine floor at the outset and, later on, covering it with a maple finish. Similarly, a concrete floor may be installed at first, later to be finished with a wood-block surface.

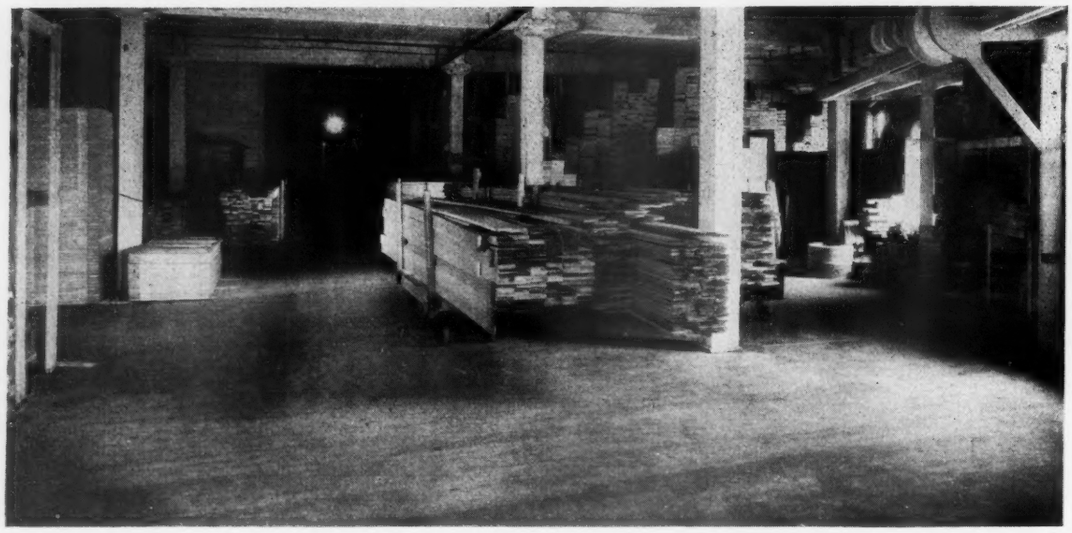
Flat-grain yellow pine, when used as finish flooring, should not be subjected to heavy service or the abuse from trucking. It will serve satisfactorily for years when used for light manufacturing. Edge-grain yellow pine offers considerable resistance to wear but costs nearly as much as maple and will not stand up as well under trucking loads.

Maple Floor—Maple makes a very satisfactory and economical flooring installation, especially in a mill-type building with its timber or steel framing and supported wooden floors. In this case the sub-floor is designed to carry the floor loads and usually consists of 2-in. tongue-and-grooved yellow pine. For the ground floor carried on a concrete base good practice requires a sub-floor under the maple, 1 in. thick for light service and 2 in. thick for heavy loads.

For the average industrial floor, where a good sub-floor is laid, maple in the standard 1-in. thickness (actually 25/32 in.) provides sufficient wearing surface. Where floors are subjected to extraordinary strain and service, a 1¼-in. thickness is recommended. The 2¼-in. width is the most popular. Widths down to 1½ in. are available and may be desirable from the standpoint of appearance. Flooring up to 3¼ in. wide is somewhat cheaper in material and labor.

Although the side and end matching of maple flooring makes a clean, even working surface, this matching may be the cause of splitting due to the slight, unequal settlement occasioned by heavy moving loads. Consequently, many manufacturers who favor maple floors insist upon square-edged maple with a face 1¼ in. thick nailed to the sub-floor, thus eliminating the possibility of splitting and permitting easy replacement.

The use of first-grade maple floor-



Maple makes an ideal floor for a woodworking plant, where loads are light and conditions are dry.

ing is justified in costly buildings open to public inspection in which a very high standard of appearance must be maintained. But second-grade maple will give practically as good service and is considerably cheaper. Many textile mills use a combination of the two grades by specifying "second grade and better."

It is highly important that a maple floor be kept dry. This precaution involves several details in connection with the installation. Maple should never be used in garages, laundries, and other buildings subject to water condition. But even with a dry occupancy water may get on the floor due to leaks in the roof, the accidental opening of a sprinkler line, or the entrance of rain through open windows. Likewise, maple flooring should be avoided in basements or on ground floors where the moisture condition is severe. Every precaution should be taken to provide a dry concrete base. The floor elevation should be established well above the general level of the surrounding drainage area. Some form of underdrainage, such as tile or cinders, will be advisable in most cases.

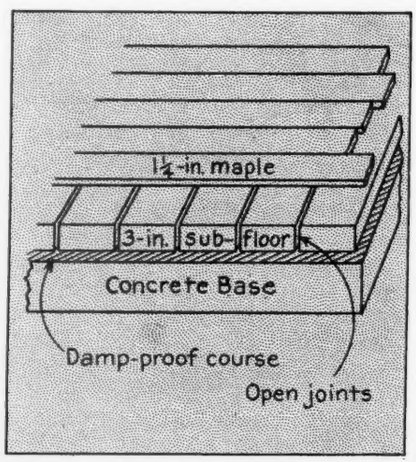
Obviously, the concrete base should be allowed to dry thoroughly before the application of the flooring. One or two coats of hot pitch should be mopped over the surface to seal off any moisture from below.

The sub-floor also should be thoroughly dry. The use of water-soaked form lumber is not advisable. Tongue-and-grooved boards not over 6 in. wide laid diagonally with the top floor are recommended. If there is any possibility of moisture, the sub-floor should be laid with ⅛-in. allowance between boards. Black water-proofed building paper generally is used over the sub-floor as an added protection against absorption of moisture by the finished flooring and to eliminate the transfer of dust and dirt through the floor.

When installed over a concrete base, the sub-floor should be nailed securely to wood sleepers, which may be imbedded in or rest directly on the base. In the latter case additional cinder-concrete fill should be provided between the sleepers to hold them rigidly in place. Sleepers should be pressure treated with creosote oil or, in any event, painted with creosote before installation. The added cost of such treatment is slight. For maximum protection and durability the entire sub-floor may be treated with creosote preservative. If the odor is objectionable, some other form of preservative oil may be used, of which several are on the market.

For a heavy-duty maple surface on a ground floor I would recommend the following construction—costly at first but requiring little maintenance over a long period of years.

Over a foundation course of standard concrete at least 4 in. thick install a damp-proof course 1½ in. thick, consisting of a combination of sand and tar mixed hot. Square-edged creosoted planks 3 in. thick are bedded and hammered into rigid position in the damp-proof course and so toenailed to the adjacent planks that they allow ¼-in. open joints. At right angles to the sub-floor a wearing surface of 1¼-in. square-edged or shallow-grooved maple is face-nailed to permit easy replacement. The substantial damp-proof course prevents the entrance of moisture from below—so often the cause of dry-rot of the entire sub-floor. This type of construction will accommodate fairly heavy machinery at any location without the necessity for special foundations.



Cross-section of a heavy-duty maple floor on a concrete base.

The laying of the maple flooring should be the last, or nearly the last, operation in the construction of the building. The building should be thoroughly dry, and the flooring should be stacked in the building at least three days before the floor laying is started, in order to acclimate it to moisture conditions in the building. Although the flooring should be driven tight, side and end, it should not be laid tight against walls or columns. Not only should provision be made at these points for expansion but, where tongue-and-groove construction is

used, a strip about 1 in. wide and parallel to the flooring should be left open every 100 ft., with the adjacent pieces planed to eliminate the tongue and groove so that square-edged strips may be inserted after a few weeks of actual service.

Maple-Block Floor—Where conditions require the use of a maple floor in basements or other excessively damp areas, it is possible to eliminate the sub-floor construction entirely and apply the floor in the form of accurately dimensioned blocks approximately 1 in. thick, 2½ in. wide, and 10 in. long. The blocks are laid directly on the concrete base in a mastic bonding material. They may be tongue and grooved or square edged and are arranged in a herringbone pattern so that the traffic in general will move across the blocks at an angle.

Wood-Block Floor—Wood-block flooring has demonstrated amply its usefulness and wearing qualities over a long period of time. Experience and practice have been fully developed so that this type of floor may be used with entire confidence.

The blocks should be sawed from good-quality, dense, long-leaf yellow pine and treated with a creosote-oil preservative to a retention of about 6 lb. per cu. ft. of timber. The treating should be performed after the blocks are sawed. The American Wood Preservers Association has prepared standard specifications covering the manufacture and installation of creosoted wood blocks for industrial purposes, and the engineer may refer profitably to these specifications for detailed information.

Wood-block floors are set with the grain of the wood vertical and will withstand an extraordinary amount of abuse. They are sufficiently durable to be used in trucking aisles, erection bays, and the like. At the same time they are resilient and quiet under traffic. Blocks 2 in. in depth are of ample size for most requirements. Where loads are excessive, a thickness of 2½ or 3 in. may be justified.

Wood blocks should be laid on a concrete base, usually 5 in. and certainly not less than 4 in. thick. The base should be finished with a wood float, and it is essential that it be free from projections. The final surface of the floor will depend to a large extent upon the smoothness of the base. The use of wood blocks over a wood subfloor construction, which usually is found in a wood frame building, is not to be recommended. The rigidity and freedom from deflection that characterize a concrete structural slab are essential to the proper functioning of wood-block flooring.

Excessive shrinkage will cause wood blocks to loosen and, for this reason, they are not suited to areas exposed to high temperatures, such as are found in the vicinity of ovens and furnaces. Similarly, rooms in which the air is humidified artificially should not be floored with wood blocks.

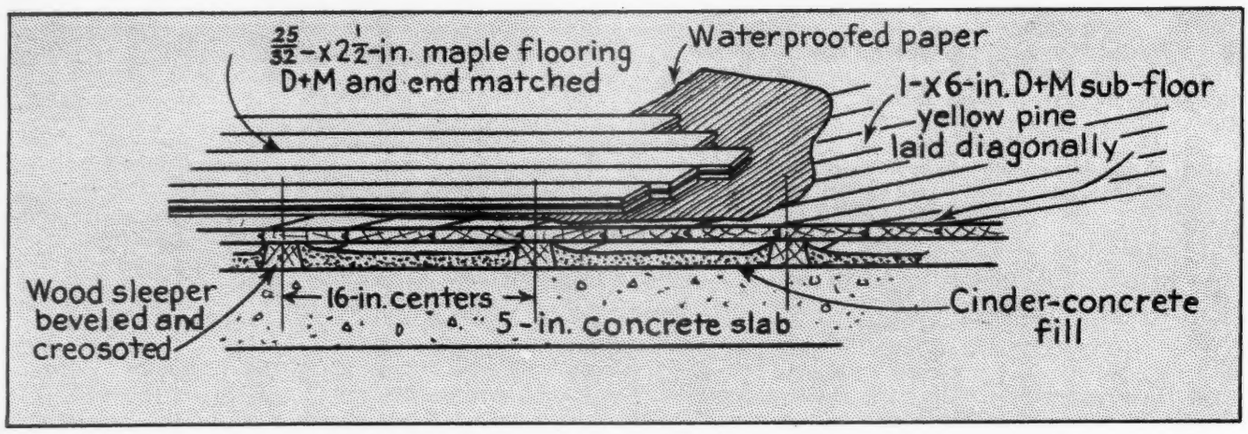
Under normal conditions any tendency toward shrinkage is overcome readily by the exercise of reasonable care in manufacture and laying. The blocks should be air-dried thoroughly before creosoting and protected from moisture at all times. When delivered to the work, they should be stored in a dry place for, even though creosoted, they are susceptible to moisture absorption.

Wood blocks are bonded to the concrete base by means of a layer of pitch. It is not necessary that the blocks be laid while the pitch is soft because the preservative oil in the block later penetrates and softens the pitch, thus developing the required adhesion. It is important that the bonding coat be continuous over the entire surface, therefore, a uniform thickness of approximately ⅛ in. is recommended.

Wood blocks should be laid across the direction of maximum traffic, with each row breaking joint with the adjoining rows by at least 2 in. Each block should be driven tight against the adjacent blocks, both sidewise and endwise. After they are in place, the blocks should be checked over carefully, and any that do not rest evenly and solidly on the base should be removed and the trouble corrected. If not corrected at the start, this fault will need to be remedied later on.

The final step in the process is to fill the joints between the blocks with pitch. The pitch filler should be applied with great care so that each joint is filled to within ½ in. from the top, this distance being measured after cooling. When a moisture condition is anticipated, wood blocks should be provided with lugs that per-

Dents in the creosoted wood-block floor of an automobile plant give mute testimony to the abuse it has withstood. It's much cheaper to dent the floor than to injure the castings.



Cross-section of a regular-duty maple floor on a concrete base.

mit expansion without damage to the floor as a whole. Otherwise, the best results are obtained by using blocks in tight contact with each other, but which are cut with grooves to permit the filler to enter the joint readily.

As a precautionary measure expansion joints about 1 in. in width should be provided around the perimeter of all wood-block floor areas, building columns, and machine foundations. Expansion joints may be filled with pitch or strips of corkboard of required depth. Expansion joints of the 1-in. width are not desirable in the body of a wood-block floor because of the effect of traffic. Where the area is large and some provision for expansion across the body of the floor is desirable, it is possible to lay a band consisting of four or five rows of lug blocks from ⅛ to ¼ in. apart. In this manner the required total expansion distance may be obtained.

The usual creosoted wood blocks do not produce a clean floor. It is not possible to keep the surface entirely free from pitch although the pitch may be reduced to a minimum by care in application. Pitch may be removed to a certain extent later.

Where cleanliness and freedom from odor are essential, consideration should be given to natural-colored block flooring, which may be sanded smooth and treated with wax or varnish until a fairly dense and attractive surface is obtained. Separate-block construction of this type is available, the blocks being treated with colorless preservative and secured to the base with a special adhesive.

Another type consists of 2-in. pine blocks in units, dove-tailed to a 1-in. sub-floor and damp-proofed with paraffin oil for interior use. The blocks come to the job attached to the sub-floor strips and are laid directly on the building floor with wood splines between each row of blocks.

Types of wood floors discussed in this part of the article have been summarized and compared in a table included in the first part, which was published in the August issue of MAINTENANCE ENGINEERING.

■ ■ ■

Self-Inspection Blank for Industrial Establishments

Courtesy National Fire Protection Association

1. Are there any accumulations of dirt or rubbish on the premises?
2. Is the basement clean?
3. Are the packing and shipping rooms cleaned up thoroughly at closing time?
4. Is there any unnecessary combustible material in the yard or court?
5. Is there any oily waste or other greasy material outside of approved waste cans?
6. Are any waste cans not emptied daily after closing hours?
7. Are there any broken windows, plastering, partitions, flooring, or other similar defects?
8. Are any aisles obstructed?
9. Are any entrances obstructed?
10. Is any woodwork or other combustible material too near steam pipes, boilers, flues, or furnaces?
11. Is the fuel supply safely stored?
12. Are there any open-flame lights near combustible material?
13. Are there any broken electric fixtures or loosened wires?
14. Are electric cords looped over nails or in contact with any other metallic objects or surfaces?
15. Are any electric fuses replaced by wire or other improper current-carrying materials or devices?
16. Are fire doors or shutters ever left open at night, or on Sundays or holidays?
17. Are fire escapes obstructed, broken or out of order?
18. Are there any violations of rules on smoking?
19. Are all water pails, hose, nozzles, and chemical extinguishers in place and in good condition?
20. Are any sprinkler heads coated or corroded?
21. Are any sprinklers obstructed by partitions, piles of goods, etc.?
22. Are any sprinklers or sprinkler pipes exposed to freezing?
23. How many sprinkler heads are kept in reserve?
24. Is there any part of the premises that the watchman fails to visit?
25. Are window openings protected from exposure fires?
26. Is combustible stock storage isolated by fire walls?
27. Where is the nearest fire alarm box?

■

Lamp Characteristics Calculator

A COMBINATION celluloid-and-cardboard slide rule which reveals the voltage operating charactertistics of Mazda lamps has just been developed by the Nela Park Engineering Department of General Electric Company.

The calculator makes it easy to determine, for any voltage condition under which a lamp is operated, the quantity of light that will be produced, how much wattage the lamp will consume and the life of the lamp.

AROUND the WORKS

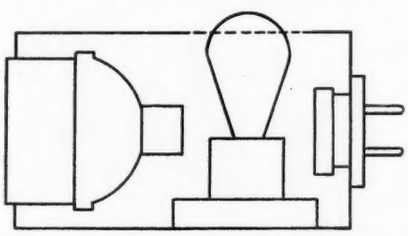
A section devoted to short articles describing practical methods devised to meet specific operating conditions. The items may refer to details of installation, inspection and testing for maintenance, wiring, repair, and replacement.

Tester for Continuity of Circuit

SOME time ago, when cellophane first was used for cigar wrapping, we installed a number of machines for the purpose. Each machine was equipped with four 100-watt, 110-volt cartridge heaters assembled in a 6-in. space. Doubt frequently arose as to whether or not the heaters were burned out. There seemed to be no way to check this point.

In order to make such a test without interrupting the operation of the machines, I built a tester, so small that it easily can be carried in the pocket. It consists of a galvanized-iron box with the sides soldered together, 3½ in. long, 2 in. high, and 1¾ in. wide. Fastened to one end is a receptacle, and to the other, an attachment cap. Situated between the two fixtures and fastened to the bottom is a 2-c.p., 110-volt pilot lamp mounted on a miniature base. The top of the lamp just reaches out of the top of the box, so that it may be changed easily if broken. One wire runs directly from the receptacle to the cap, while the other runs through the lamp.

By plugging the heater leads into the



tester and the tester into the receptacle, we now are able to test the heaters quickly for continuity of circuit while the machines are in operation.

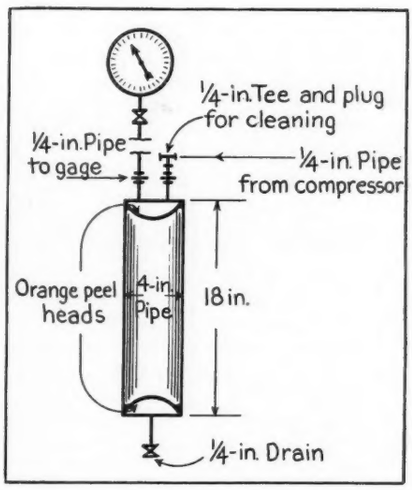
G. W. LANCASTER.

Electrician Foreman
Waitt & Bond, Inc.
Newark, N. J.

■

"Drip-Pot" for Pressure Gage

WHERE a pressure gage is subject to heavy pulsations, such as on a compressor line, its life and accuracy can be prolonged by using a "drip pot" or reservoir.



This device acts as a catch or trap to prevent any oil or moisture, which may be in the medium to be gaged, from being drawn into the gage mechanism.

The drip pot can be made from a piece of 4-in. pipe about 18 in. long with orange-peel welded heads at the ends. A ¼-in. nipple and valve in the lower end is used to drain off the accumulated oil and moisture. Two ¼-in. nipples are used at the upper end, one going to the gage and the other in the line coming from the compressor.

Arcadia, Calif. M. C. COCKSHOTT.

■

Kink for Maintenance Drawings

IN MAINTENANCE work it is often desirable to make drawings showing the location of wiring circuits, motors, switches, and other electrical installations. Where it is desired to show the location of the machinery, columns, walls, etc., on the blueprints, these items ordinarily add to the difficulty of drawing and complicate matters, especially in cases in which a machine or circuit is shifted and the drawing must be changed accordingly.

One Eastern concern has adopted a plan for making the tracings that has simplified considerably the making of such corrections. The layout of the machinery and building usually is traced directly from some other tracing. Instead of tracing such items on the front of the tracing cloth, both tracings are turned over and the outlines traced on the back. In this position, both tracings show the outlines in the opposite hand.

The tracing cloth is then turned over and the circuit laid out in the front. Lines can go directly across a machine outline without complications when inking in. A circuit can be erased and moved without having to erase and redraw the machine and building outlines that have been crossed. This plan is used not only for electrical circuits but also for pipe lines and other service features.

Sometimes it is necessary to make the tracing of a layout from a blueprint which obviously cannot be traced from the back. This handicap is overcome by placing a sheet of carbon paper underneath the blueprint with the black side against the back of the blueprint. The draftsman goes over the outlines of the sections he wishes to show, using a blunt pointed rod or a pencil. Using a pencil, however, spoils the blueprint by darkening the white lines, but it is easier to tell when a line is missed by this method. The carbon paper transfers onto the back of the blueprint every line traced on the front. When the blueprint is turned face down, the outlines are in reverse and ready for tracing. The use of a thin transparent paper between the blueprint and the tracing cloth prevents the carbon from smudging the cloth.

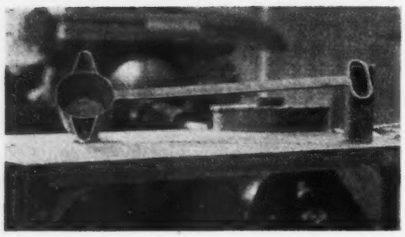
Chicago, Ill. F. E. GOODING

■

Welder Fabricates Handy Babbitt Ladle

THERE is shown in the accompanying illustration a babbitt ladle made by the welder of a New York hotel, which the machine shop has found very useful in pouring new bearings. It has a long handle and two lips with a bottom feed so that the molten metal poured is free from slag.

In making the lips, ⅛-in. steel was heated by a blowpipe flame and forged



Babbitt ladle with bottom feed fabricated by welding.

into shape. The body was made by shaping a cylinder from ⅛-in. steel. A bottom plate similarly cut out was secured in position. The lips were then welded on as shown. The handle, heated and forged from ¼-in. steel, also was welded to the body.

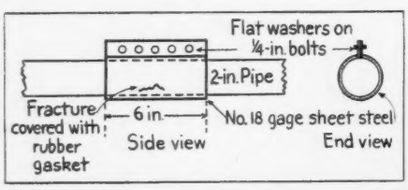
It has been found that the ladle is a useful piece of shop equipment, particularly where the great variety and number of machine bearings makes re-babbitting a frequent operation.

■

Temporary Repairs for Broken Water Pipes

CRACKING of a water pipe in our plant in the middle of the day almost caused operations to come to a standstill. We could not lower the pressure because we needed all water in the line for production. To continue operations we made temporary repairs as shown in the sketch.

After placing a piece of rubber gasket material over the crack, we covered it with a band of 18-gage sheet steel, 6 in.



Side and end views of clamp used to effect temporary repairs to a fractured water line.

long with two flanges, drilled for ¼-in. bolts. The flanges were located on the side of pipe opposite to where the crack developed. This clamp held the pressure until we changed the pipe that night.

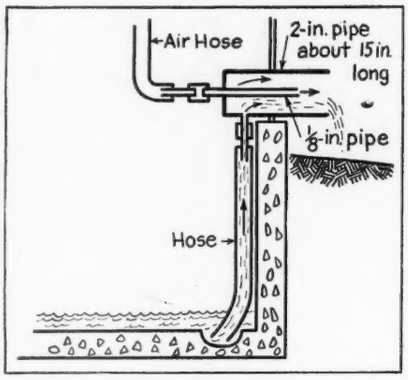
R. M. THOMAS.
Denver, Colo.

■

Ejector for Sewage Drainage

OWING to settling caused by a poor foundation, a concrete floor in the basement of our water-treater building cracked badly and shifted enough to hinder drainage into the sewer. One end of the floor dropped about three inches, causing the presence of a thin sheet of water over the floor at all times. Operators were handicapped by the uncomfortable working conditions. Digging a trench was out of the question because it would have weakened the floor so much that it probably would have cracked again in the other direction. Changing the location of the sewer to suit the new slope also was out of the question because of its cost.

Our welder solved the problem by means of the simple ejector shown in the sketch. The ⅛-in. pipe is welded in the center of the 2-in. pipe. Regular ⅛-in. fittings are used at the two hose connections to take the ⅛-in. nipples used in the air hoses. The lower hose leads to a small hole chipped in the floor. All the operator has to do is to turn on the air a little while before he goes down in the basement. The other day I noticed that he had a long air hose hooked up to it and was using it as a vacuum sweeper to pick up some of the soda and lime scattered over the floor.



R. F. PETRIE
Brooklyn, N. Y.

■ ■

Special Table Design Speeds Up Cafeteria Lunches

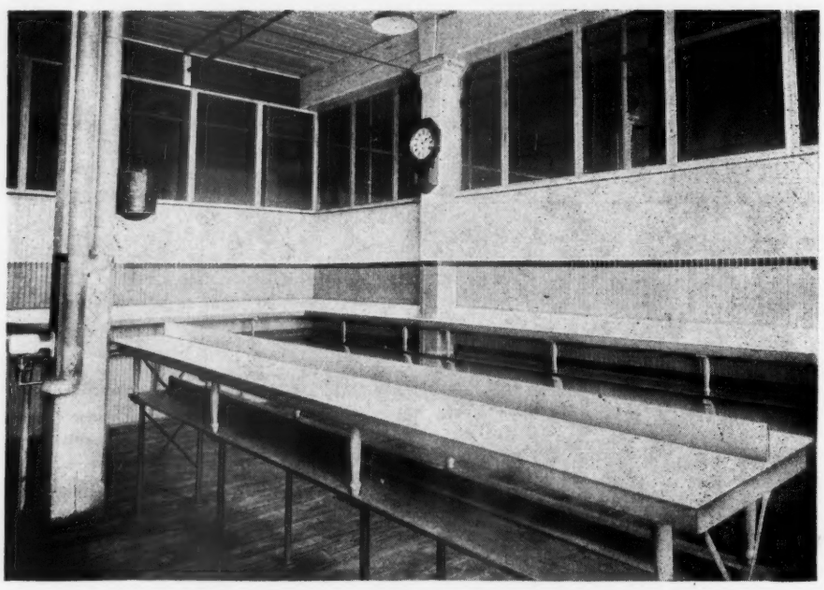
WE HAD the problem of feeding several hundred people in about twenty minutes at noon time. The entire layout of the lunchroom depended upon the method of handling the soiled dishes. A cafeteria system was devised to serve the food, but no time was allowed to return the soiled dishes to the kitchen. The way we overcame this difficulty in the room for the employees was to provide shelves under the benches, which were to be used as serving tables during the course of the meal.

We found that we could not provide space for individual tables and chairs, therefore the tables were built so that the employees could stand up to their lunches, which arrangement saves space and furnishes a speedy method of serving.

When an employee has finished his meal, he removes his dishes from the table top and places them on the shelf below and, after all have been served, the lunchroom employees go about the room removing the soiled dishes.

This method has worked out satisfactorily in speeding up the serving time. Also, it has eliminated the necessity of hiring additional help during the noon hour to remove the dishes to the kitchen. We have four lunchrooms equipped in this manner, all operating with equal success. The white top of this table is made of glass and is supported on a wooden frame, as shown in the accompanying illustration.

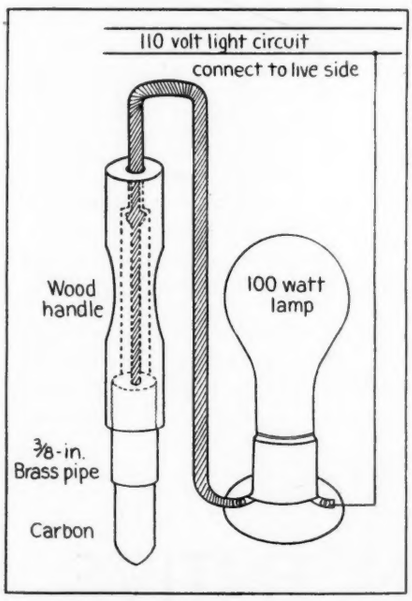
K. D. HAMILTON.
Mechanical Department
Geo. E. Keith Company
Campello, Brockton, Mass.



Shelves built under the tables expedite the feeding of several hundred employees when time and space are at a premium.

Carbon Gas Lighter Substitutes for Matches

AN UNSIGHTLY condition, which existed around a gas stove in a machine shop because of the match sticks and empty match boxes that the workmen threw about, was remedied by the carbon gas lighter shown in the sketch. The wood handle was obtained from a portable extension light, while a piece of ⅜-in. brass pipe, threaded about ¾ in. on one end, was used to hold the carbon. The cord was attached to the carbon holder by passing the bared ends through a brass washer, then tying it in



Gas lighter made from odds and ends to remedy an insanitary condition resulting from using matches.

a knot and soldering it to the washer. The washer in turn was inserted into the pipe and soldered to it, and finally the pipe was screwed into the handle.

The lighter, in series with a 100-watt lamp, was connected to the positive wire of the lighting circuit. To light the stove the gas is turned on and the lighter touched to the burner.

A. A. A. RODRIQUES.

New York, N. Y.

■

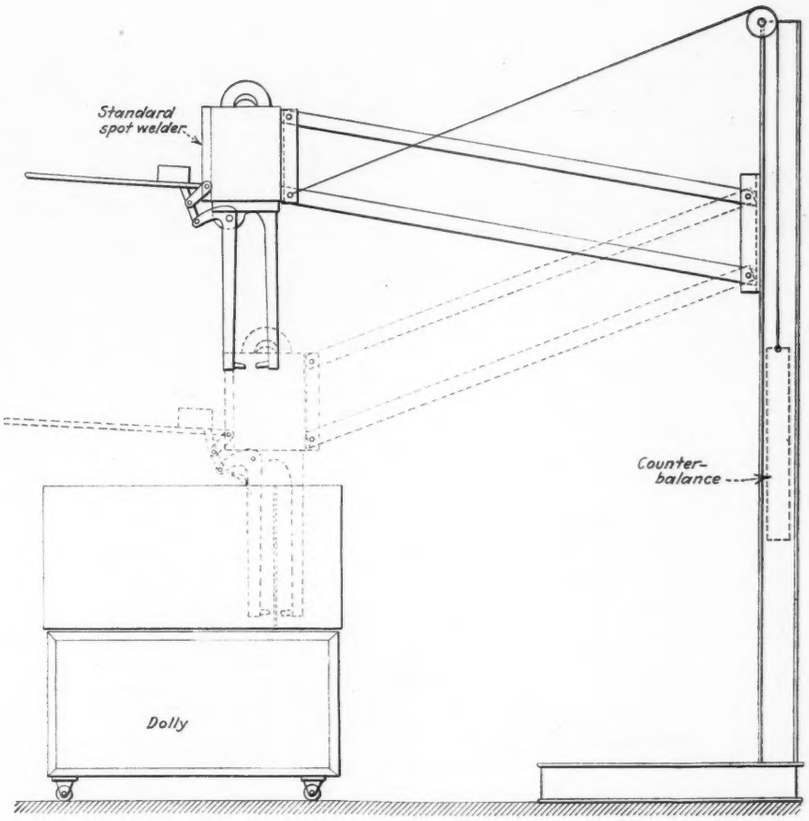
Mounting Spot Welder to Facilitate Operation

IN ORDER to handle properly one of our spot-welding jobs, a different method of mounting the welder had to be devised so that the operator could see his work and also get the welder into position more readily. These objectives could not be accomplished with a welder in which the arms are in a horizontal position.

The accompanying sketch shows how we eventually solved the problem by mounting the welder in a vertical position on two parallel arms, so that it can be moved up and down with the arms always in a vertical position. The welder is counterbalanced to make manipulation easier.

The work is placed on a caster dolly which can be moved in any direction. With this arrangement the operator is able to spot many places that were former impossible to reach.

Any spot welder with a removable base can be mounted in this manner.



The spot welder is mounted on hinged parallel arms attached to a strong upright. A counterweight permits the welder to be raised and lowered easily.

Plant Engineer,
Highway Trailer Company
Edgerton, Wis.

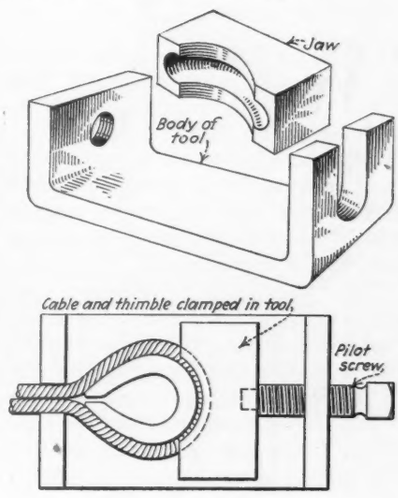
L. E. DANA.

■ ■

Tool for Assembling Thimbles in Steel Cables

WHEN fitting thimbles in cables, splicing wire-rope slings, and so on, some means of holding the cable firmly in position will greatly facilitate the work. A tool that has been designed for this purpose is shown in the accompanying illustration. It will prove to be a valuable aid in working on the cables used around the shop hoists and cranes.

The manner in which the tool is used in fitting a thimble, for example, will be evident from the illustration. Aside from holding the cable thimble firmly in place while the clamps are being fastened on, this tool has the advantage that it can be gripped in a vise or held in any convenient way, so that the workman can use both hands.



Washington, D. C. G. A. LUERS.

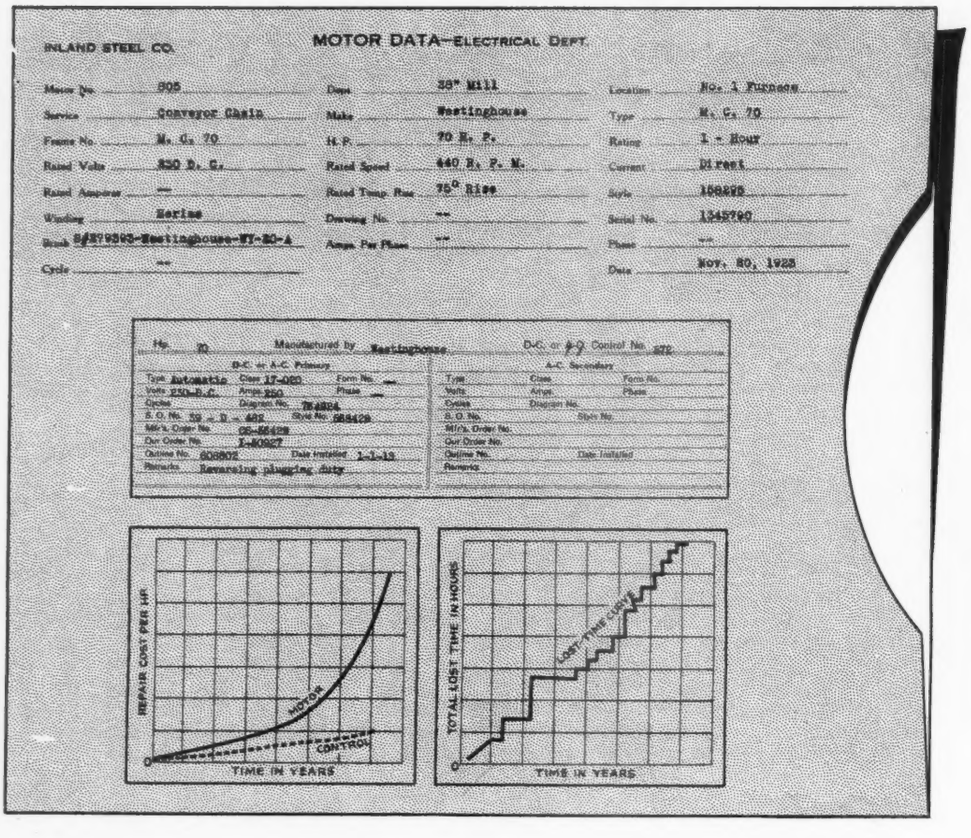


Fig. 16 — Manilla envelope, 10x12 in., in which records are filed, and on the outside of which data are recorded.

MAINTENANCE ON INCENTIVE

Maintenance Cost Records That Defy the Tooth of Time

FRED W. ACKER
Assistant Superintendent
Electrical and Power Departments
Inland Steel Company, Chicago, Ill.

■

Third and Concluding Article

"WHEN guesswork comes in the door, efficiency flies out the window." With the increasing competition in the steel industry the guesswork method used in arriving at the maintenance cost of drives must give way to a system which presents the actual operating data to the management.

The duties of the maintenance organization are to present the exact cost to the engineer in charge. In the past it has felt that the main duty was to repair existing equipment and get it back into operation with minimum delay. In the average case the cost of this work was not known and seldom did the maintenance organization care. On the other hand many times the members of the maintenance organization were over-conscientious. They would spread the time spent on the job, when they felt that it was abnormally long, to jobs which required little time. By so doing they would, in their opinion, avoid the criticism of their supervisors. Such practice is unsound and defeats any program the management may have in retiring equipment when its maintenance costs become excessive.

In the replacement program the electrical engineer is looking to the maintenance organization for two

things, cost of maintenance, and delays in hours, both of which are factors contributing to high operating costs. He must continually watch these expenses with an eagle eye. Therefore the most logical place in which to file these data is in the electrical superintendent's office where they will be under his supervision and observation continually.

It is not difficult to obtain accurate test, service, and maintenance cost data when trouble occurs; but to record them so that they can be presented on a moment's notice seems to be a difficult task. The Inland Steel Company's Indiana Harbor Works has devised a system whereby these costs can be recorded daily in such a manner that at the end of the year their totals, when graphed, will give the electrical engineer the trend of the operating costs of any drive at a glance.

Any discussion of operating expense will always center around a specific drive; thus it is logical that a record system should be set up "as per drive." The manilla envelope shown in Fig. 16 serves a three-fold purpose. (1) It provides a place to file data such as electric department repair records, service and motor data cards, and any test data, such as graphic charts taken on the drive. (2) On the front it gives the location and service of the drive as well as the nameplate data of the driving motor and its control. (3) It provides two cross-section squares on which cost and performance graphs may be plotted.

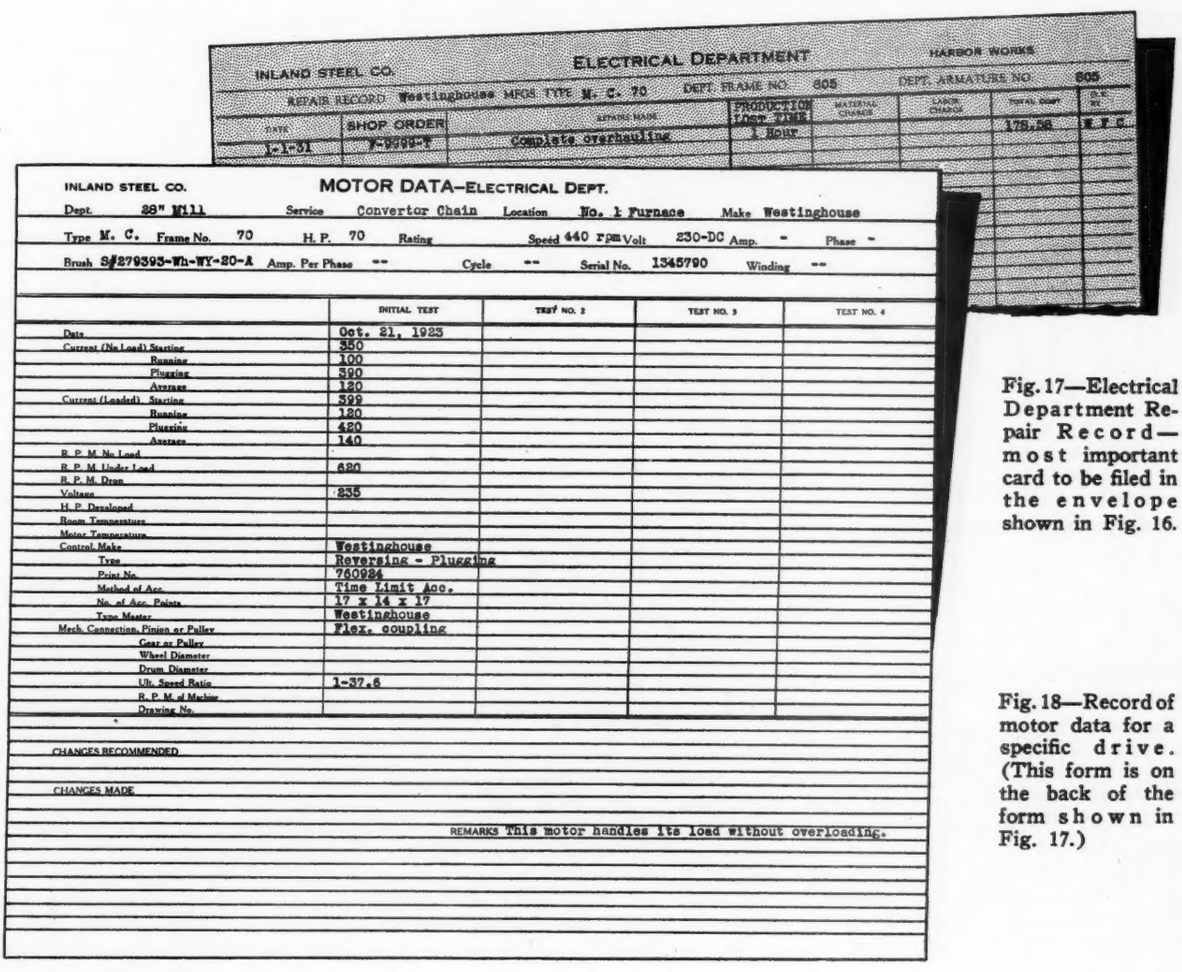
The repair costs of the electrical equipment each year are plotted in the left-hand square. A separate curve can be plotted for the motor and control if desired. The right-hand square is used to graph the production lost time, either in hours or dollars. As the years pass these curves will be silent "records that will defy the tooth of time."

The electrical department repair record, Fig. 17, is the most important card to be filed in the envelope. It gives the dates of installation and repairs of the motor or control, lists the repairs made, the stock order on which these repairs were made, the lost time caused by the equipment failure, and the complete cost, including labor and material. Many times questions arise as to the accuracy or fairness of a certain repair cost. For this reason the shop order number is included so that the complete costs may be reviewed.

Many equipment failures are accompanied by costly production lost-time hours, which in many cases are more expensive than the cost of the repairs. Therefore no maintenance cost record is complete without this feature being included in the record card. These values can be recorded in hours or converted into money values.

The back of the repair record card is utilized for the motor data of the drive involved. See Fig. 18. It is essential to take an initial test of any motor when it is first installed, including the important factors set forth on this card, that they can be used for future comparison. This card is self-explanatory.

Most drives of any importance in a steel mill have spare motors available for replacement in case of failure. They may be available for several drives. For this reason the service record card is provided for each motor frame and each armature. Separate shop numbers are applied to



INLAND STEEL CO. — ELECTRICAL DEPARTMENT — HARBOR WORKS

REPAIR RECORD Westinghouse MFGR. TYPE M. C. 70 DEPT. FRAME NO. 805 DEPT. ARMATURE NO. 805

DATE	SHOP ORDER	REPAIRS MADE	PRODUCTION LOST TIME	MATERIAL CHARGE	LABOR CHARGE	TOTAL COST	O. K. W. C.
1-1-31	C-19992-T	Complete Overhauling	8 Hour			178.56	W. F. C.

INLAND STEEL CO. — MOTOR DATA—ELECTRICAL DEPT.

Dept. 28" Mill Service Convertor Chain Location No. 1 Furnace Make Westinghouse

Type M. C. Frame No. 70 H. P. 70 Rating Speed 440 rpm Volt 230-DC Amp. - Phase -

Brush S#279393-Wh-WY-20-A Amp. Per Phase -- Cycle -- Serial No. 1345790 Winding --

	INITIAL TEST	TEST NO. 2	TEST NO. 3	TEST NO. 4
Date	Oct. 21, 1923			
Current (No Load) Starting	350			
Running	100			
Plugging	590			
Average	120			
Current (Loaded) Starting	590			
Running	120			
Plugging	420			
Average	140			
R. P. M. No Load				
R. P. M. Under Load	620			
R. P. M. Drop				
Voltage	235			
H. P. Developed				
Room Temperature				
Motor Temperature				
Control Make	Westinghouse			
Type	Reversing - Plugging			
Print No.	760924			
Method of Acc.	Time Limit Acc.			
No. of Acc. Points	17 x 14 x 17			
Type Master	Westinghouse			
Mech. Connection, Pinion or Pulley	Flex. coupling			
Gear or Pulley				
Wheel Diameter				
Drum Diameter				
Ult. Speed Ratio	1-37.6			
R. P. M. of Machine				
Drawing No.				

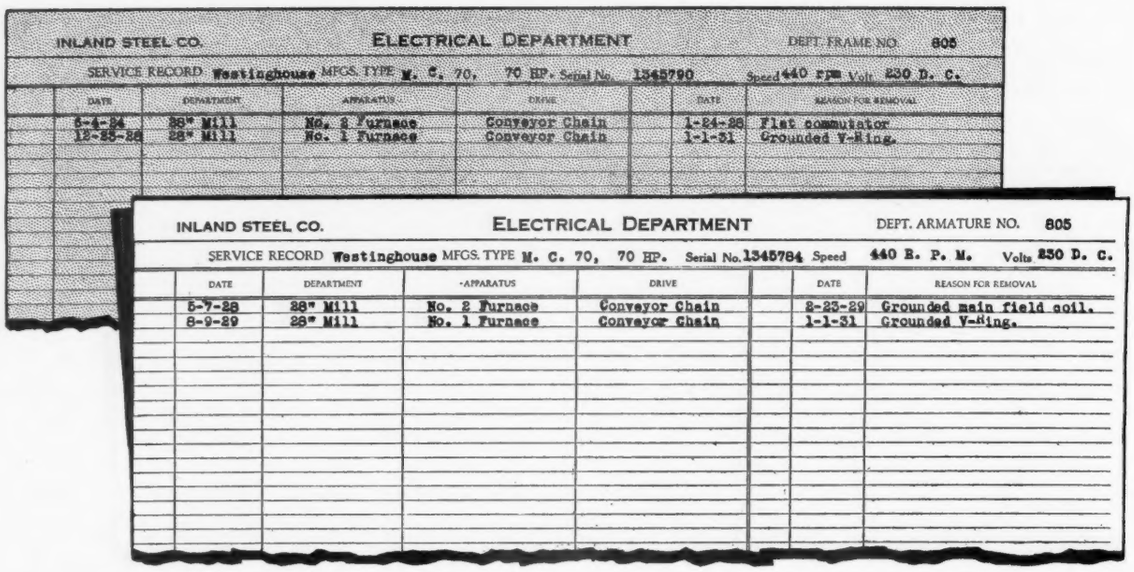
CHANGES RECOMMENDED

CHANGES MADE

REMARKS This motor handles its load without overloading.

Fig. 17—Electrical Department Repair Record—most important card to be filed in the envelope shown in Fig. 16.

Fig. 18—Record of motor data for a specific drive. (This form is on the back of the form shown in Fig. 17.)



INLAND STEEL CO. ELECTRICAL DEPARTMENT DEPT. FRAME NO. 805

SERVICE RECORD Westinghouse MFGS. TYPE M. C. 70, 70 HP. Serial No. 1345790 Speed 440 rpm Volts 230 D. C.

DATE	DEPARTMENT	APPARATUS	DRIVE	DATE	REASON FOR REMOVAL
6-4-24	28" Mill	No. 2 Furnace	Conveyor Chain	1-24-28	Flat commutator
12-25-28	28" Mill	No. 1 Furnace	Conveyor Chain	1-1-31	Grounded V-Ring.

INLAND STEEL CO. ELECTRICAL DEPARTMENT DEPT. ARMATURE NO. 805

SERVICE RECORD Westinghouse MFGS. TYPE M. C. 70, 70 HP. Serial No. 1345784 Speed 440 R. P. M. Volts 230 D. C.

DATE	DEPARTMENT	APPARATUS	DRIVE	DATE	REASON FOR REMOVAL
5-7-28	28" Mill	No. 2 Furnace	Conveyor Chain	8-25-29	Grounded main field coil.
8-9-29	28" Mill	No. 1 Furnace	Conveyor Chain	1-1-31	Grounded V-Ring.

Figs. 19 and 20—Service Record Cards, for individual motor frames and armatures.

each. See Figs. 19 and 20. When a new motor is received the frame and armature will bear the same number, but no attempt is made to keep them together. The first failure may be a roasted armature requiring a complete rewind. In order to make the motor available for immediate service another armature is placed in this frame, and the original armature then becomes a spare after it has been repaired.

The file folder for each drive will contain the service record card for an armature and a frame. Each of these cards will give a complete history of its respective sojourns throughout the mill, listing the date installed, departments, apparatus, and service it was performing. It also shows the date of and the reason for its removal.

These cards do not show any repair costs. It is a simple matter to pull the file folders for the different drives to which the motor was connected and to obtain the complete cost data from the repair record cards inclosed.

When the frame or armature is out of service the service card is placed in numerical order in the spare files. When reported in service it will then replace the service card in the file of the drive it is going to work in, and the motor removed for repairs will become a spare, as soon as it has been repaired.

This system is very simple to keep up to date and you will derive its full value from its use alone.

[*The second article of this series of three appeared in the August issue, the first article in the July issue.*]

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BOOKS

Vector Representation for Electrical Metermen

By D. T. Canfield, Associate Professor of Electrical Engineering, Purdue University. McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Cloth Binding, 5½x8 in., 180 pages, diagrams and brief trigonometric table. $2.

IN THIS book Mr. Canfield has creditably done what long has been considered impossible—he has explained, in a clear and well-chosen sequence, vector notation as applied to electrical calculations, presenting his subject in such a way as to be grasped by the man with little or no mathematical training. Although the author might be criticized by a strict logician for introducing and using concepts before proving them valid, it should be recognized that the book was written to provide useful mental tools for practical men, rather than to present a pragmatic mathematical treatise.

Especially commendable is the manner in which power factor is introduced. It is first defined and discussed in terms of meter readings, and only later, after the discussion of a few fundamental mathematical relations, is it treated as the cosine of an angle.

The idea of vectors as expressing quantities defined in terms of direction as well as of magnitude is presented in a similar circumspect manner. An explanation of phase relations, and of the time element in the conception of rotating vectors, follows. Energy measurements and power factor correction are then discussed at some length.

The book is a valuable contribution to electrical exposition, for it does much to tear away the unnecessary awe with which "vectors" seem to be surrounded in the eyes of practical men in the field.

Effect of Calcium Chloride as an Admixture in Portland Cement Concrete

THE INVESTIGATION covered in this 81-page booklet, designated as Engineering Experiment Station Bulletin No. 61, was conducted by Ohio State University Engineering Experiment Station, in cooperation with the Calcium Chloride Publicity Committee. The effect of calcium chloride on the rate of hydration of portland cement and its constituent minerals, other effects of calcium chloride on portland cement, and the final state of the calcium chloride were studied. X-ray determination of the combination of calcium chloride with calcium hydroxide was made.

The bulletin contains a complete bibliography and numerous tables and charts. Copies may be obtained without charge by addressing the Engineering Experiment Station, Ohio State University, Columbus, Ohio.

BANDS FOR ROTOR END WINDINGS

A. C. ROE

Renewal Parts Engineering Department
Westinghous Electric & Manufacturing Company, East Pittsburgh, Pa.

END WINDINGS of all rotors must be restrained against the action of centrifugal force, which tends to throw them outward. On squirre-cage rotors the end or resistance rings hold the bars in place; with some of the older types of these rotors running bands of steel wire were used. On rotating armatures of the hand- or machine-wound type, where consecutive coils overlap the preceding ones, it is merely necessary to fasten together the ends of the last two coils wound in. However, on rotors wound with the two-layer, coil-end type of winding, it is necessary to employ steel or bronze wire bands to hold the end windings in place.

This article will deal with the selection of the size of wire, width of bands, and number of layers of bands to hold the end windings against the distorting action of centrifugal force set up by the combination of speed, weight, and extension of the rotor end windings.

Size of wire selected depends to a great extent on the airgap, with surface core bands, and upon the centrifugal force for most cases. The following table based on rotor diameter indicates the safe size of wire, as shown by long experience:

ROTOR DIAMETER		WIRE DIAMETER
Up to 10 in.	use	0.029 in.
10 to 16 in.	use	0.045 in.
16 to 24 in.	use	0.064 in.
24 in.	use	0.081 in.

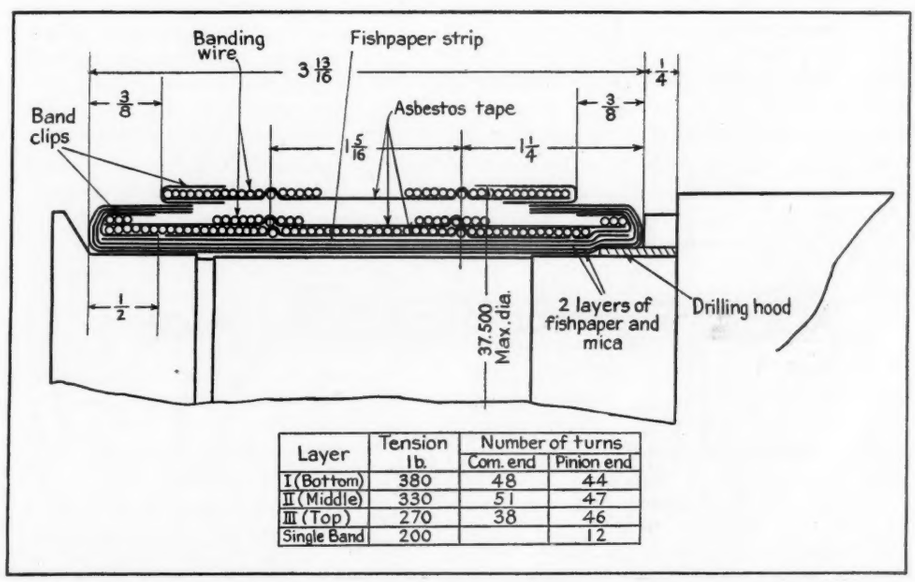
For rotors or armatures up to 10-in. diameter a soft-finished, 0.029-in. tinned-steel banding wire is used; above 10-in. diameter a hard-finished, tinned-steel wire should be used.

Banding clips to hold the wires of each band together are made from 0.005-in. tinned sheet copper, for 0.029-in. wire on armatures up to and including 10-in. diameter. Above 10-in. diameter, 0.013-in. tinned-sheet-steel clips are used, except in the case of railway and some mining motors, on which 0.022-in. tinned sheet steel is used.

WIDTH OF CLIPS

Clips should be ½ in. wide for all bands, and should be long enough to extend at least ¼ in. on both sides of the finished band.

The spacing of clips for armatures up to 10-in. diameter should be approximately 4 in. between the center lines of the clips. For armatures of 10-in. to 16-in. diameter the spacing should be 5 in. between the center lines; 16-in. to 24-in. diameter, 6 in. between centers; above 24-in. diameter, 8 in. between centers. This spacing is sufficient to hold the bands together, without excessive circulating currents.



Layer	Tension lb.	Number of turns	
		Com. end	Pinion end
I (Bottom)	380	48	44
II (Middle)	330	51	47
III (Top)	270	38	46
Single Band	200		12

Fig. 1—Details of three-layer band on commutator end of a heavy-duty, a.c. rotor.

WIDTH OF BANDS

The width of bands, as mentioned before, depends upon the speed, weight of coil ends, size of banding wire, and allowable space for bands.

A formula that can be used for determining this factor is:

Width of Band = $(D \times W \times B \times T) \div S$

where D = Diameter of rotor

W = Weight of coil ends

B = Band stress as given in Table I

T = Diameter or thickness of banding wire

S = Allowable stress per wire, from Table II.

TABLE I—FACTORS FOR BAND STRESS IN END WINDING BANDS

R.P.M.	Factor B	R.P.M.	Factor B
100	0.023	1,200	3.26
200	0.091	1,300	3.82
300	0.203	1,400	4.43
400	0.362	1,500	5.09
500	0.565	1,600	5.79
600	0.814	1,700	6.53
700	1.11	1,800	7.33
800	1.45	2,000	9.04
900	1.83	2,400	13.02
1,000	2.26	3,000	20.35
1,100	2.74	3,600	29.31

Table I gives the value of B for speeds ranging from 100 to 3,600 r.p.m. that should be used in the formula. For speeds between those given in Table I use the value of B corresponding to the next higher speed. For example, for 750 r.p.m. use the value of B given for 800 revolutions per minute.

Table II gives the allowable stress, S, that can be used for each wire, with the diameter or thickness, T, of each wire.

TABLE II — FACTORS FOR WIRE STRESS IN END WINDING BANDS

Diameter of Wire, T	Allowable Stress Per Wire, S
0.029 in.	22
0.045 in.	80
0.064 in.	160
0.081 in.	280

The weight of the coil ends should include the part extending out past the core; W in the formula means the weight of the coil ends on one end of the armature. In the majority of cases it is advisable to calculate the weight of the coils on the rear end. When the total weight of a set of coils is known, the weight of one end winding can be found by measuring the slot section and end portion of one coil and using the proportion of the total length of the end to the whole, to distribute the copper weight. The coil can be measured closely enough for this purpose while it is in place on the rotor. For example, consider the end band for an armature 24 in. in diameter, running at 1,200 r.p.m. The coil ends weigh 70 lb. We would use 0.081-in. diameter, hard-finished steel wire, with 0.013-in. thick tinned-sheet-steel clips spaced on 8-in. centers. From Table I it is found that B equals 3.26 in this case. From Table II S is seen to be equal to 280, and T equals 0.081 in. Then according to the formula, the width of the band in inches is $(24 \times 70 \times 3.26 \times 0.081) \div 280 = 1.58$ in. Thus, a 1½-in. band should be used.

The width of end bands should be varied in ¼-in. steps; that is, use the next largest fraction, as ¾ in., 1 in., 1¼ in. and so on. When the width of band required exceeds the space available, use two or three layers of bands, as wide as the space will permit.

In Figs. 1 and 2 is shown a three-layer band on the coil ends of a heavy-duty, a.c. rotor. Each layer is divided into three sections, each section being insulated from the adjacent section by a single layer of asbestos tape. The layers are also insulated from each other by asbestos tape. The table given with Fig. 1 indicates the tension applied to each layer of the banding wire. Thus, Figs. 1 and 2 show how to split bands to reduce heating to a minimum and still obtain a light and solid retaining band.

The formula given above can also be used to determine the width and number of core bands. For W use the weight of the slot portion of the coils and divide the width of the bands into an even number of ⅜-in. or ½-in. wide bands. If bands wider than ½ in. are needed, each band should be divided into two sections insulated from each other.

In the case of core bands the air-gap will govern the size of wire that can be used, and the value of S in Table II will affect the width of the bands.

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"Lcode"—Electrical Industry Telegraph Code

A COMPLETE industry telegraph code has been attained by the electrical industry. A Joint Industry Committee, made up of representatives from seven major associations, has compiled "LCODE," "a telegraph code book of standard five-letter combinations for the electrical industry, including all words and phrases commonly used in the purchase and sale of electrical equipment and supplies."

Under NEMA sponsorship, the following groups have united in the production of this pioneer effort: Association of Electragists, International; National Electric Light Association; National Electric Wholesalers' Association; Radio Manufacturers' Association; Radio Wholesalers' Association; and the Society for Electrical Development.

LCODE will go into effect within six weeks from publication (November 1). At that time a list will be issued to each holder advising him of all other holders. This list will be kept up-to-date. The code is published in book form by The Business Code, Inc., 2 Rector St., New York City.

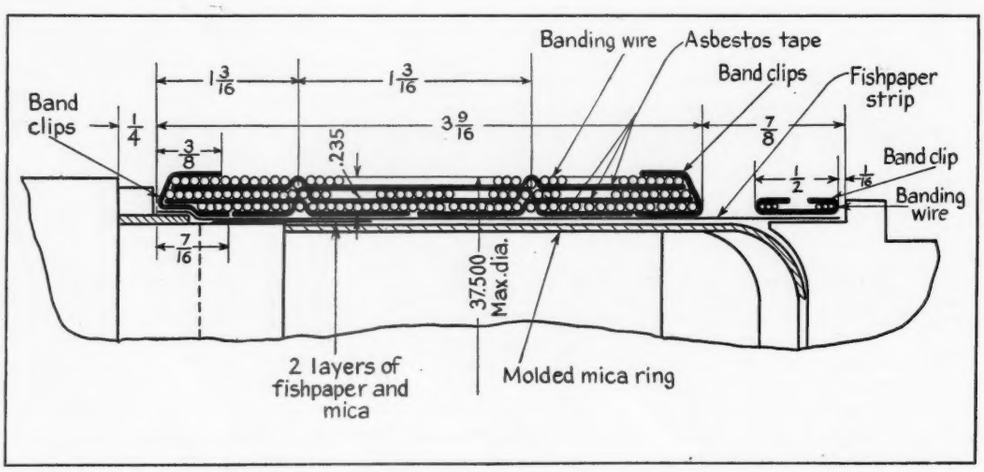


Fig. 2—Three-layer band on pinion end of the rotor shown in Fig. 1.

Steel lockers arranged back to back in a separate building located near the plant entrance. Heated by unit heaters, well ventilated, and well lighted, this building provides every facility for employee welfare.

Lockers—A Plant Asset

FRED D. HARTFORD
Denver, Colo.

EVERY employer, to secure better service and improve the morale of employees, can capitalize on the need for a place in the plant they can call their own.

Numberless workers do not have personal tools, or even the same chair or machine from day to day. In fact, nothing about the factory ties them, or gives them a feeling of possessing a place in the organization. Of course it is not possible, nor is it necessary, to give each employee a private office or a desk of his own.

The answer to this need of the employee is simple. Provide each employee with a locker of his own.

Every workman should be encouraged in pride in his personal appearance, inside the plant as well as outside. The nature of most factory work demands that he change his street clothes for his work clothes. If he can put his belongings in a locker where they are protected against theft, dirt, odors, vermin, and dampness, he goes to work in a better frame of mind than he does when he must pile his good clothes along with those of other workers, some of whom perhaps are none too clean, in some dark corner of the plant.

Suppose that the employer has decided that lockers will be not only good welfare, but also good business. What sort of lockers shall be choose? There are lockers and lockers, and in many cases the first suggestion is almost always this:

"I will have the carpenters build substantial wood lockers, and they will be good enough."

And he will be partly right. Wooden lockers are infinitely better than no lockers. But usually they will cost more than the best steel lockers of the same size. I once had an experience of just this sort when I thought I could save some money. I had the carpenters build lockers using good lumber and first-class hardware throughout. The lockers looked all right; they were well-built, and were given two coats of good paint; however, they cost $13 apiece, whereas the best steel locker of the same size was quoted at $11.50. Steel lockers, in addition, are more easily cleaned; they are fireproof; and they stand up better under the severe treatment that is almost certain to be their lot.

Careful consideration of the number and arrangement of lockers for the factory is warranted so that the best possible results may be obtained for the money expended. Naturally, every employee will prefer separate compartments for clean clothes and for shop garments. This is particularly true where the shop clothes smell of paint, oil, or perspiration. Two small lockers may be better than one large one in cases of this kind. Some locker makers provide a wire basket with a pulley and chain device whereby shop clothes can be hoisted up to the ceiling, and the arrangement locked with the same padlock

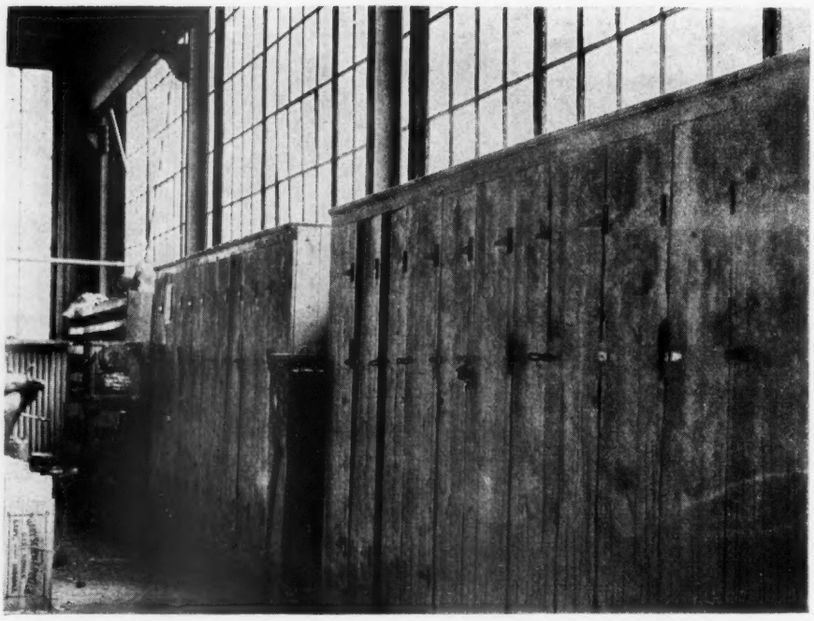
that serves the locker itself. This scheme has the advantage that shop clothes are thoroughly aired and dried, while the locker itself is kept clean for street clothes.

If possible, a locker should be large enough to accommodate an overcoat hung on a hanger. Also, it is desirable for the locker to have a shelf. However, if any sacrifice must be made, I believe that the employee would prefer to have the shelf omitted and the space utilized to provide more clothes room. To prevent the piling of old clothes on or under lockers, it is customary to mount the lockers on a solid concrete base six or eight inches above the floor, and to provide them with a sloping top.

The location of the locker room in the plant is important, if maximum is to be secured. In many cases the locker room is placed near the gate so that the change of clothes is the first order of business in the morning and the last in the evening. All lockers placed in one building render supervision easier than when they are scattered around the plant in small units, and if shower baths are provided they should be placed near the lockers so that scantily-clad men do not need to parade up and down cold corridors. Whether the locker room shall be locked up except for certain hours of the day will be a problem for each plant.

Supervision of locker rooms, to insure order and cleanliness, sometimes presents a serious difficulty because not all employees have the same standards of personal hygiene. Among some workmen there is a thrifty habit of never throwing away any old clothes, possibly with the idea that the old clothes may some day come in handy. As a result lockers become cluttered with numerous garments that are dirty, greasy and malodorous. In some plants the lockers are inspected at intervals by the foremen who are provided with master keys. Owners of dirty lockers are then requested by the foreman to clean up. The results are not always satisfactory, as good workmen often have chronically dirty lockers and take orders to clean up as a joke.

One factory found a better way to get results. A committee of employees who had previously served on the safety committee and had been imbued with an appreciation of good plant housekeeping, were appointed to inspect lockers every two weeks. Alibis that sometimes got by the foremen inspectors did not influence this committee. An infallible remedy for the most obstinate cases was found to consist in putting the offender on the inspection committee for a time. About once a year the superintendent of the plant went around with the inspection committee.



Wooden lockers answer the purpose, but are less sanitary and less durable than those made of steel. In addition, they usually cost more than steel lockers.

In every factory there are a few employees who fail to respond to generous treatment and to conveniences supplied by the employer. The average employee reacts favorably to clean and orderly surroundings and feels that he is a part of the organization. A locker for each employee will go far in promoting this desirable plant morale.

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Standards for Zinc-Coated Steel and Iron

AMERICAN Tentative Standard specifications for zinc-coated (galvanized) sheets of bessemer steel, open-hearth steel, and open-hearth iron have been approved by the Amer- Standards Association. Five classes of zinc coatings, applied by the hot-dipped process, are covered in the specifications, as follows:

Class A — Extra heavily coated sheets that are not intended to be formed other than by corrugating.

Class B — Heavily coated sheets that are not intended to be formed other than by corrugating and curving to large radii.

Class C—Moderately heavily coated sheets for moderate bending.

Class D—Ordinary coated sheets for general utility.

Class E — Sheets having lighter, more tightly inherent coating to reduce liability of flaking in severe forming.

Class D coatings approximate those of Class C except in medium gages in which coatings of Class D are appreciably lighter.

The standard includes sections dealing with chemical properties and tests, physical properties and tests, base-metal tests, coating tests, permissible variations, finish, marking, and inspection and rejection. Provisions for minimum requirements when copper is used in the base metal, requirements for weight of the zinc coating including a table of weight of coatings by ounces per sq.ft., provisions for base-metal tests, and a table showing gage rings and permissible tolerances in weights of sheets in percentage of theoretical weight are also included.

The standard was submitted to the American Standards Association by the American Society for Testing Materials, sponsor for the project. Copies may be obtained from the American Standards Association, 29 West 39th St., New York, at 25 cents each.

Distributing the Electrical Energy

R. G. HORNBERGER
Electrical Engineer
Cleveland, Ohio

In the preceding article, in the August issue, some of the details that should be given attention in laying out industrial plant substations were discussed. Distribution of energy from the substation to the various load centers and thence to the point of utilization are taken up in this, the concluding, article.

MAIN feeders to the principal plant sub-distribution centers can be run either overhead or underground. Overhead lines have the advantage of low initial cost, relatively high overload capacity, and the ease with which taps can be made. They have the disadvantage of high maintenance, danger from lighting and storms, and unsightly appearance. They are a dangerous obstruction to fire fighting equipment. Where overhead lines are used, they should be constructed in accordance with the rules of the National Electrical Code and the National Electrical Safety Code of the Bureau of Standards. Details of materials and standard designs may be obtained from the NELA Reference Book on Overhead Construction. Reference may be made to standard texts on the design of overhead lines. A good method of computing sags is given in the Standard Handbook for Electrical Engineers.

Underground lines have the advantage of permanency, low maintenance cost, and freedom from danger due to lightning. Although their initial cost is considerably higher and their overload capacity is not great, as compared with overhead lines, the extra cost of an underground duct system is fully justified in the majority of cases.

There are several tables published by manufacturers, which give the carrying capacity of cables in ducts.* The values given are usually conservative. During the past few years much more study has been given to the fundamental theory involved. If it is desired to load a cable in an underground duct up to the limit, reference should be made to the more recent literature.

For an underground distribution system that is somewhat less reliable and permanent, but considerably lower in first cost, parkway cable may be used. This is a cable that is designed to be laid directly in the ground. It is made in two principal forms. The first has, in addition to the usual rubber or cambric insulation, a lead sheath, one or more layers of asphalted jute, and a steel tape amoring protected by a jute covering. The second form has a non-metallic covering that is waterproof and resistant to cuts and abrasion. Parkway cable should not be used for the higher voltages, say 2,300 volts and above, unless thoroughly protected from mechanical injury.

In determining the size of conductors for overhead or underground lines, the voltage regulation, or voltage drop, and the power loss must be considered. For any lines within the scope of this article, the voltage regulation can be computed from the following formula:

$$E_o = \sqrt{(E\cos\phi + RI)^2 + (E\sin\phi + XI)^2}$$

Where E_o = Voltage at the supply end*
E = Voltage at the load end
Cos ϕ = Power factor at load end
I = Amperes per wire
R = Total resistance per wire in ohms
X = Total reactance per wire in ohms

Values of R and X per unit of line can be obtained from many published tables. In very short lines, especially underground lines, the effect of reactance can be neglected. In any line that is long in proportion to the voltage used, reactance should be considered.

The question of power loss in the conductors, the chief factor in the determination of economic size, is one of balancing the increased first cost of larger conductors against the decreased cost per year of the power lost in the lines.

In many cases limitation of first cost will prevent the most economical size of conductor from being installed.

Sub-Distribution Centers

Each feeder, or group of feeders, will terminate in a sub-distribution center. The considerations in plan-

*See also "Electrical Characteristics of Transmission Lines" by Wm. Nesbit.

*E_o and E are voltages from line to neutral. For single-phase systems E_o and $E = \frac{1}{2}$ the line voltages and for three-phase systems E_o and E equal the line voltages divided by $\sqrt{3}$ or 1.73. The factor, $\frac{1}{2}$, in the single-phase case arises from the fact that the current, resistance, and reactance of only one of the two lines are considered.

ning sub-distribution centers are just the same as for the main distribution center, except that the currents in general will be much smaller. Frequently all that will be needed is a power panel containing mains and a group of fused knife switches.

Distribution of power to individual motors can be made by one of two general methods. The first gives uniform coverage, whereas the second supplies a power line to each definite motor location. For uniform covering, it is necessary to divide the building into unit areas, such as column bays, and then to determine the maximum load expected in any area, together with the highest load factor. The product of the two gives the amount of power which it is necessary to provide for each bay or unit. This is usually done by running a feeder to a cutout cabinet on a column in each bay. Distribution is then made from this cabinet directly to the individual motor and control by one of the methods to be discussed.

In the other method, individual lines are run directly from the sub-distribution center to the pre-determined motor locations. Spare conduits are run to the probable locations of future motors.

The method of uniform coverage may be economical or desirable when the motors are small, when there will be much moving of machinery, or when the future loads cannot be predicted closely. With large motors, and when the future conditions can be predicted, the second method is more economical.

With a uniform-coverage system, distribution to the cutout cabinets involves individual feeders in conduit. Several methods can be used for distribution to the motors. One employs exposed conduit. Another uses underfloor duct, either metal or fiber, with pre-set or after-set outlets. A patented type is available that employs rubber hose cast into the floor and later removed. Recently an overhead duct system has been placed on the market. The ducts are about 4 in. square and in sections. Knockouts are provided so that taps may be taken off at any convenient location and additional wires laid in as desired.

There is also available a system of buses, inclosed in sections of steel duct, with the necessary turns and fittings so that a complete conductor system covering a given area can be constructed of standard, factory-built sections. Frequent openings are provided for the insertion of a jack to which a motor lead may be attached. The underfloor duct systems are admirably fitted where there are many small motors. The two overhead duct systems have found their principal uses in automobile plants, along assembly lines. Probably the greatest number of power wiring systems still use only the simple conduit and wire to each motor.

Planning becomes simpler when the location of each motor is known, because the control equipment can be located at the motor. Another method is to group the controls for several motors on one rack. This seems to be the present trend, as it simplies maintenance, makes a better looking plant, centralizes the electrical apparatus, and costs little more. If there are explosive or corrosive gas mixtures present, it is usually cheaper to inclose a group of starters in a separate, ventilated room than it is to provide each motor with an explosion- or vapor-proof starter.

Where starters are grouped, it is necessary to provide a rack, usually of pipe and strap iron, bus insulators and buses and disconnecting switches between each starter and the bus. If there are thermal cutouts on the starters, or if the current-interrupting capacity of the starters is not large, it is necessary to have a set of fuses between each starter and the bus. When the motors are not within sight of the starters, it is necessary and convenient to have a push-button control station near the motor. The Code will sometimes also require a disconnecting switch (usually an unfused safety switch) in the main motor leads, if the motor is not within sight from the starter.

If manual starters are used, each may be mounted near the motor controlled. In that case it is usual to provide a disconnecting switch at each starter. No fuse is required in this switch if the line is fused where it leaves the power panel or sub-distribution center, and if only one motor is fed by that line.

Where corrosive or explosive gases are present, gas-tight control equipment can be used. A better solution in most cases is to group all the control equipment in a separate room that has either good natural or forced ventilation. In that case the starters must be of the remote-controlled type.

In calculating wire and conduit sizes for individual motors, current-carrying capacity and voltage drop must be considered. Current-carrying capacity is now specified by the Code for any given motor size and type. It is based in general on the principle that the continuous carrying capacity of the wire should be 125 per cent of the normal full-load current of the motor, to allow the wire to carry the starting inrush current safely.

The voltage drop should not, in general, exceed 5 per cent. In the case of motors with a heavy starting duty, especially motors started directly across the line, the voltage drop at starting may be so high that the motor will not develop full torque. In such cases, the voltage drop when starting current is flowing should be limited to 10 per cent.

Where several motors are supplied by one feeder, and there is a probability that all the motors will be runing at any one time, the feeder should be designed to carry the starting current of the largest connected motor plus the running current of all the other motors. If the above condition will never be realized, a demand factor may be applied.

Reactance drop is normally neglected, although in the case of large, important motors it should be checked, particularly at starting, as reactance drop affects the regulation much more than resistance drop at low power factors.

Distribution for Lighting Systems

Distribution for lighting systems will depend on two main factors: intensity required and type of control groups required. Illumination intensities have rapidly been increasing ever since electric lighting has been used commercially. Present recommended values of illumination can be secured from many sources.*

It has become accepted practice to place larger groups of lights under control of one switch. In some plants contactors or remote control switches are used to control entire factory bays from one station. There are available now at least two forms of vacuum tube control relay which will automatically turn on the lights if daylight fails and turn them off when it increases. In any case, it is customary in large areas to control the lights by means of the branch switches in the panelboards. In offices, storerooms, and similar areas, local switching is essential.

The usual system voltages are as follows:

1. 115-volt, single-phase, two-wire, a.c. and d.c.

*See National Lamp Works Bulletin No. 41-D on Illumination Design Data.

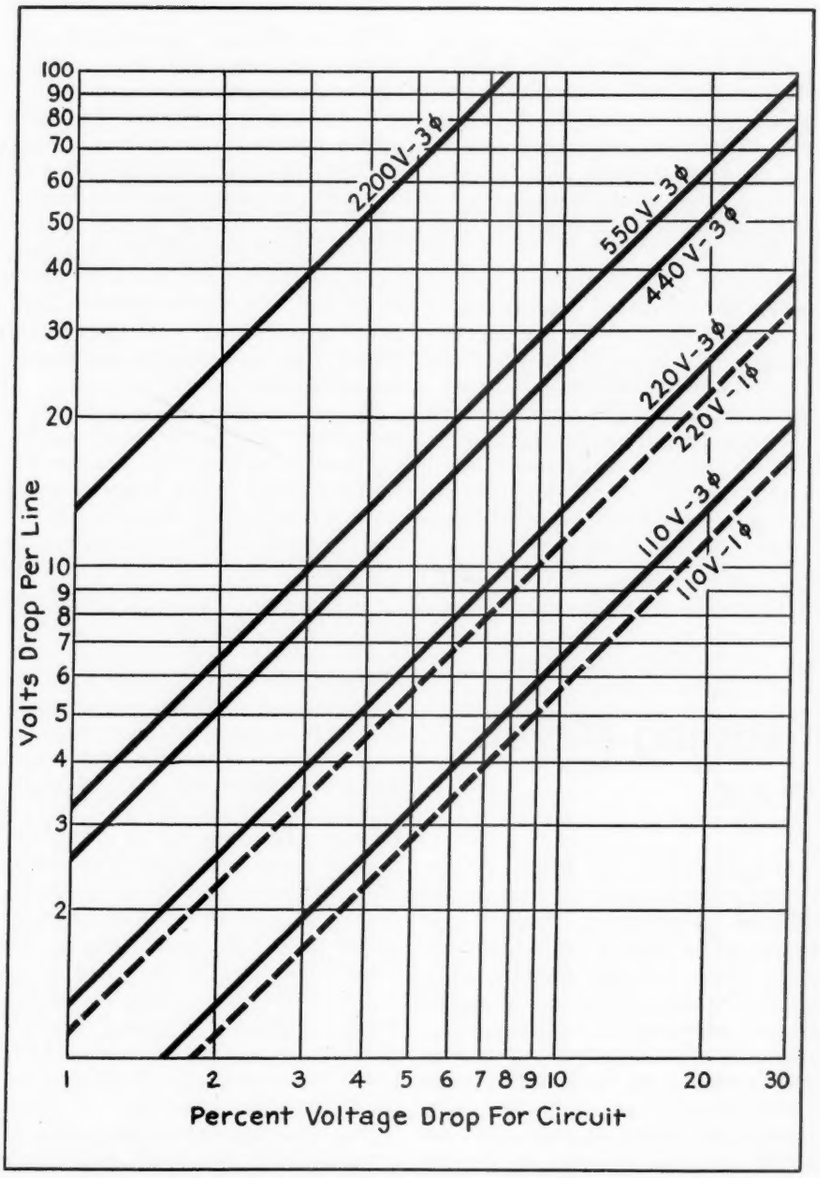


Fig. 4—When the volts drop per line is known, the percent voltage drop for the circuit can be determined from this chart.

2. 115/230-volt, single-phase, three-wire, a.c. or d.c.

3. 230-volt, single-phase, two-wire, a.c. or d.c.

4. 208-volt, three-phase, four-wire. a.c.

5. High-voltage distribution with transformers located at strategic points, which transform the voltage to one of the above values.

The 115/230-volt, three-wire system has been widely used. The three-wire lines are carried to the panelboards, from which the branch circuits are run as two-wire, 115-volt circuits. The advantage is that energy is transmitted to the panelboards at 230 volts, with attendant low voltage drop, and the efficient 115-volts lamps can be used.

The 208-volt, three-phase system has been adopted by several large power companies. It is a three-phase system, with a solid metallic neutral carried as the fourth wire. The three phase wires give 208-volt, three-phase current, whereas a 120-volt, single-phase load can be fed from any phase wire and the neutral. This system gives still greater copper economy than the 230/115-volt system. Power and lighting loads can be supplied from the same set of feeders.

In some localities the inspection authorities permit even branch circuits to be run as four-wire circuits, which means that four wires will carry three single-phase circuits, whereas under the old system six wires would be required. The voltage drop will be less for the four wires than for the six.

The use of the fifth system mentioned has been made more practicable by the current development of a line of air-cooled, oilless transformers. The Code will allow such transformers to be placed at any convenient location in the building, without requiring a special vault. In this way a large area can be covered by running, for example, 440-volt feeders to load centers, where these transformers step it down to 115 volts (or 230/115 volts, or 208 volts, three-phase, four-wire). A system of this kind is obviously economical for large areas only.

Branch circuit wiring may be run exposed or in a metallic raceway. The exposed system should not be considered, except for temporary work, or work that may be altered frequently. Conduit may be black enameled, galvanized, or thin wall. Galvanized conduit should be used for all work exposed to the weather, in damp places, or where the conduit is buried in concrete. Thin-wall tubing is similar to galvanized conduit, except that it has thinner walls, and threadless fittings must be used. This type is not yet approved in all localities for installations where it is buried in concrete.

In selecting the wire sizes, there are two factors to consider: carrying capacity and voltage drop. Carrying capacity may be determined directly from the tables in the National Electrical Code. In computing voltage drop, resistance only need be considered, because lighting loads have very good power factors. Various formulas and charts have been devised for computing the voltage drop in lighting circuits. The accompanying chart can be used to determine quickly the per cent voltage drop of a circuit. The lighting system voltage drop should be restricted to 3 per cent from source to lamps. A good division of this drop is 1 per cent in the feeders to the panelboards and 2 per cent in the branch circuits between the switchboards and the lights.

In designing feeders to panelboards, a demand factor may be used. The Code now specifies the demand factor to be used for the usual types of commercial structures. The demand factor for industrial plants may vary from about 40 per cent or less for storage spaces or other areas with individual light switching, to 100 per cent for large, single areas.

Panelboards are well standardized. The mains may be provided with lugs

only, fuses, or fused switches. The switches may be of the open-knife, or the safety type. Where individual feeders are run to each panelboard, lugs only are required in the mains. However, where several panelboards are supplied from a common feeder, fuses, or switches and fuses, in the mains are desirable. The rather common practice of providing sub-feeds from one panel to another is not desirable, as it throws too many fuses in series. Trouble on one panel will affect all others fed from it.

Specifications

Specifications are necessary for all electrical work that is let out on contract. The prime purpose of specifications is to interpret the requirements and limitations of the work to be done. The length of the specifications should be kept to a minimum by covering all the details of construction, wire and conduit sizes, and types of fittings and fixtures, in the drawings. The specifications should be used only to set forth such items as scope of work, methods, the securing of permits, and similar general conditions.

There are available many suggested forms for electrical specifications, most of which cover the general conditions well. None of them will fit exactly the requirements in most specific cases. In drafting specifications a certain amount of judgment must be used, and it must be remembered that they are not written just to show engineering and legal phraseology, but rather to explain in as simple a manner as possible the general requirements of the job.

■ ■

Simple Methods of Testing Motors

W. O. HURLBUT

San Francisco, Calif.

INDUCTION motors other than the squirrel-cage type can be tested easily by opening the secondary circuit and exciting the primary with normal or, preferably, greater than normal voltage. This applies to single-phase repulsion as well as polyphase, wound-rotor machines.

Raising the brushes and exciting the primary will produce torque in the rotor at certain points, if the secondary is short-circuited. If clear, the rotor will float freely in all positions. A short circuit in the primary will also show up by excessive heating, due to local currents. This scheme has the advantage of not necessitating removal of the rotor, and the test can always conveniently be made when the motor is connected to the line.

The repulsion motor responds readily to this test, except when the double-winding type is encountered. With a squirrel-cage winding imbedded in the core, it is obvious that the rotor cannot be so easily tested by merely putting magnetic flux through the iron.

In the case of squirrel-cage rotors, which can hardly develop shorts, but are subject to opens, a similarly simple test is convenient. Opens in this type of rotor are very easily overlooked. When winding a stator the rotor is often given no more than a casual inspection, and unless a fault is very apparent it is not likely to be detected. Fortunately, squirrel-cage rotors of the later types seldom develop faults, but the adoption of a standard test for all rotors leaving the shop is, nevertheless, justified.

For machines up to a certain rating, depending on the capacity of the testing circuit, a suggested test is to reverse the motor at full speed on double voltage. A faulty bar contact will expose itself under this severe strain, whereas any small rotor in good operating condition should not be damaged by this rigorous treatment. Even the high-resistance, high-torque rotors used in elevator service have been tested in this way without injury. I have tested machines up to 10 hp. on 100-amp. fuses with double voltage, and up to 20 hp. on rated voltage, with 200-amp. fuses.

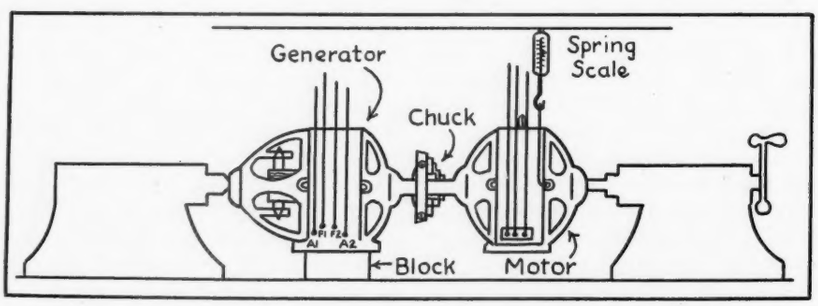
After a little experience has been gained and the acceleration of various machines observed, the tester becomes proficient in recognizing whether or not a motor develops proper torque. The weight of the rotor is, of course, an important factor to consider when observing the performance. Poor characteristics of an improperly brazed rotor are surprisingly apparent under this test.

When it is necessary to test motors for torque and horsepower, advantage can be taken of the fact that the torque exerted in the frame is equal and opposite to that developed in the moving member. After experiencing the disadvantages of other methods of testing, the simple arrangement shown in the illustration was used.

The motor and generator are mounted on centers, as shown, either in a lathe or between center posts arranged in any convenient way for this purpose. Thus the motor and generator shafts are not only self-aligning, but the torques of either or both can be measured at all speeds.

A universal chuck on the generator shaft will accommodate motor shafts of various sizes, and can be used with larger or smaller generators, as desired. The load is dissipated in an external variable resistance. Separately exciting the generator will simplify output calculations and permits the generator to act as a tachometer. With separate excitation of fixed value, the armature voltage is directly proportional to the speed, and a voltmeter can be calibrated to indicate the r. p. m. and voltage simultaneously.

As the generator can be inverted and driven as a variable-speed motor, by applying direct current from an external source, this arrangement lends itself readily to the ingenuity of the operator in making various tests.



Measurement of torque and other tests can be simplified by mounting the motor and generator between lathe centers. A universal chuck is used to connect the motor and generator shafts. The generator is blocked up to prevent turning.

Bonus System for Electrical Maintenance

A. I. GREENWOOD

Chief Electrician
United Verde Copper Company
Clarkdale, Ariz.

ALTHOUGH the installation of a bonus system for maintenance work is a more difficult task than for manufacturing processes, it is not an impossibility. A bonus has been paid for electrical maintenance in the plant of the United Verde Company, Clarkdale, Ariz., for several years.

The following list of plant departments gives an idea of the amount and character of electrical equipment maintained by means of incentive systems: ore crushing, fine grinding, flotation, roasters, reverberatory furnaces, copper converters, traveling cranes, industrial railway system, "Cottrell" precipitation, coal pulverizing, power plant, and shops. More than 600 electric motors in the plant total 20,000 horsepower.

Three methods of applying the bonus system are in use, each method being best adapted to the conditions existing in the division in which it is employed:

1. *Straight 25 Per Cent Bonus*—This method is used in cases in which a maintenance electrician regularly covers a route consisting of more than one department. Although under the supervision of a foreman, he is given full responsibility for the condition of all electrical equipment included in the route. His duty is to inspect all motors and starting equipment at regular intervals and to make all necessary repairs and adjustments that he has time to perform. If major repairs are needed, he reports the case to the foreman who either sends a helper or delegates the job to others. Any repair work that is done by an electrician other than the maintenance man is compensated for by means of a *time standard bonus,* which is described later under its own heading.

Bonus is paid on the following basis: If all equipment on the route operates satisfactorily and causes no delays in production for the month, the electrician is given a 25 per cent bonus. But if delays occur, deductions are made from the bonus, a predetermined amount being deducted for each 30 minutes of delay on each machine.

An objection to this arrangement frequently raised is that it is possible for a maintenance man to "get by" for a while with few delays and still not keep the equipment in satisfactory condition. However, this possibility is eliminated by adequate supervision. The big advantage of this method is that the electrician takes a keener interest in his work because he has been given a greater responsibility. He knows that if he does better work he will receive more pay.

An alteration of this plan is now being considered that is expected to be an improvement. The maintenance man will be given an itemized sheet listing the exact inspections to be made while traveling his route. The sheet also will list all minor repairs that should be made at regular intervals. A daily time standard will be set for the work. The workman will receive extra pay equal to his regular rate for half the time saved. For example, suppose a time standard of six hours per day is set for a certain maintenance route, with all inspections definitely outlined. If the maintenance man can do the work in four hours, he will have saved two hours and will receive pay for one extra hour. In this case the bonus amounts to 25 per cent. If he can do the work in less than four hours, he will receive more than a 25 per cent bonus. Major repairs, not listed under the regular inspection, will be paid for on a separate bonus plan, based on a time standard.

This revised method also will carry a penalty for delays to prevent the maintenance electrician from slighting his work in the hope of getting more bonus. Under the existing plan there is no special incentive for the maintenance electrician to make his own repairs, as will be the case under the revised plan.

2. *Time Standard Bonus* — This method is based upon the amount of work to be done and is used for general repair work. The question might arise as to how a standard can be set on a repair job that never has been done and for which the amount of work cannot be predetermined. In such a case the bonus man sets his standard time either by inspection of the work while in progress or by reference to a detailed list or description of the work, submitted to him after it is completed. Often such new jobs are made up of a number of component parts which already have standard times set for them.

3. *Cost Standard Bonus*—This plan of bonus payment is used in all cases in which the maintenance work in one department requires the full-time services of one man or more. In this method the maintenance man shares in the bonus of the operating department in which he works, the bonus being determined by the unit cost of production of that department. Under such an arrangement the maintenance electrician will do his best to prevent production delays and lower his material and labor costs because he knows that his work will be reflected in his pay envelope. I have found this method to be very satisfactory where the department is not too large.

MAINTENANCE ENGINEERING

L. C. MORROW, Editor

SEPTEMBER, 1931

Shy a Stone at Mrs. O'Leary's Cow

FIRE-PREVENTION week is near again. October 4-10 is the date. Even though you think that your plant is as well protected as possible against fire, give it an extra check-up during or prior to fire-prevention week.

All of us pay fire losses—in actual money, higher insurance rates, loss of life, damaged equipment, and ruined materials.

Each of us has a personal responsibility to prevent fires. Busy as we are in keeping down expenses and building up net profits we are likely to be neglectful of fire hazards.

Published on another page of this issue is a "Self-Inspection Blank for Industrial Establishments," prepared by the National Fire Protection Association. Just to make sure, have a responsible member of your staff make an actual inspection and fill out the blank.

One Side, Diffidence!

EVERY man can remember wifely supplications, extending over many days, looking toward his getting a haircut. He can remember, also, finally taking the plunge, only to find it necessary to point out the improvement after waiting expectantly for dear wife to congratulate him on his increased beauty.

Wives are that way and nothing can be done about it. Inattention is a human characteristic. Probably if a man walked along Main Street on the hottest day of the year togged out in his winter overcoat he would have to carry on a continual ballyhoo if he wanted to leave with other pedestrians anything more than a fleeting impression.

In merchandising, the human animal's proneness to inattention has been recognized, and to combat it good "packaging" has been adopted. The advertising profession has recognized that there must be something about its wares to get attention. The progress of almost every commodity sold can be attributed largely to attention-getting procedure in connection with its merchandising.

And when it comes to merchandising services —the services of people—there is good packaging, too—sometimes. But seldom is packaging good in the case of the engineer, especially the maintenance engineer.

With the increasing recognition of the maintenance function, the maintenance engineer must learn more about ballyhoo—packaging—attention—merchandising services—call it what you like. When he has done something of importance in his plant he must make certain that management learns about it. Perhaps the plant has had no breakdowns for a long period—who will realize how smoothly things have been running, unless the maintenance engineer tells them? Perhaps he has saved money in this way, or that way—it's likely that he'll have to say so.

Performance records, analytical records, charts, reports, can be some of the media by which he can get his accomplishments given attention. A judicious amount of talking about his own department will help. Tactful insistence upon specific programs will be necessary at times. By inclination retiring, he must acquire temerity, abrogate diffidence.

Less Guesswork—More Know—About Galvanized Sheet

RECENT adoption by the American Zinc Institute of a seal of quality for galvanized sheets is to be regarded as a commendable, forward step that will be advantageous to both producer and consumer.

It has long been established that the thickness or weight of the zinc coating is the dominant factor in determining the length of time that galvanized sheet can remain in service before rusting occurs. Customarily the weight of the coating is expressed in ounces per square foot, which is interpreted to mean the total weight of zinc on both sides. Thus, a 2-oz. coating indicates 1 oz. of zinc per square foot on each side. Heretofore, there has been no simple means whereby the purchaser could distinguish adequately coated products from those that are not, and in view of the rather wide variation in the weight of coating on commercial sheets the principle of "buyer beware" has had more intensive application than is desirable. Under the new plan, galvanized sheets bearing the Zinc Institute Seal of Quality will be marked with the weight of the zinc coating.

For use in rural communities sheets will be available in No. 28 and No. 26 gages, coated with 1.75 oz. of zinc per square foot, which is considerably more than is used on most commercial sheets at present. Sheets of No. 26 gage and heavier stock, carrying 2- to 2.5-oz. coatings can

be had for locations where the service is severe.

Galvanized sheet has several qualities that make it highly useful in industry. The producers have acted wisely in giving consumers a simple means of specifying and judging the quality of their product.

Your Money and Your Plant's

"SPEND your plant's money as you would your own." There probably are few among the readers of these columns who have not at some time heard this trite rule and noted its wisdom, especially those in charge of equipment purchases. But, as with many other maxims, it has grown commonplace.

The average man instinctively uses his best judgment in deciding upon a purchase when the money must come from his own pocketbook but, when his plant's money is at stake, factors such as company policies, procrastination, or lack of initiative are likely to intervene and warp his judgment. Many men, who would jump at the chance to put their money in a safe stock or bond returning them 10 per cent, hesitate to spend their company's money in equipment that assures a 25 to 50 per cent return.

Others, who trade in their automobile for a new one when the cost of repairs and low mileage show them that to do so is most economical in the long run, make no move to replace in their plant equipment that is eating up profits in excessive costs of maintenance and repair.

Buy on Price—and Other Considerations

ONE of the advantages claimed for immediate purchase of equipment for replacement and modernization is that low prices can be obtained. It is a real advantage; competition during depression has been responsible for some fine bargains. The alert maintenance engineer will take advantage of them in making his recommendations and specifications.

Yet he must be on his guard. Not always does the item that carries the lowest price give the greatest value. Here is no new thought in the pages of *Maintenance Engineering;* probably it is not new to many of our readers. It deserves repetition at this time because right now the temptation to buy on price alone is very strong.

When orders are rolling in, a full force is working full time, and money for equipment is in plain sight, the thought that price may have an approximately true relation to service is easily entertained. Perspective changes as prosperity sluffs off. It becomes necessary after so long to take prejudice back to zero, readjust perspective, and start all over.

The procedure as a whole will resolve itself into a careful consideration of the job for which the equipment is required, the service that it may be expected to render, and the price at which it can be bought. After these steps have been taken, decision may have to be made either to lower service expectations that selection may be accommodated to pocketbook, or to maintain service standards even though such action must be accompanied by greater expenditures. In either case it's wise to base the decision upon a knowledge of facts, not merely upon a difference in prices.

Sweeten the Pot—You'll Draw More From It

BEGINNING soon, *Maintenance Engineering* will publish a series of articles dealing with the use of small installations of materials-handling equipment. The length of the series has not been determined. Part of the material has been collected by the editors; it is hoped that the remainder will be furnished by the readers of *Maintenance Engineering.*

Emphasis always has been placed on big, impressive installations of materials-handling equipment. Both manufacturers and users of these installations have been justly proud of them. But in many plants big installations cannot apply. Because of high sales cost the small installation has been neglected, to the detriment of the manufacturer of materials-handling equipment and to the detriment of the industrial plant that should be, but is not, using such installations.

Let's do some educational work. Let's show some of the small installations that are in use. You readers of *Maintenance Engineering*—send to the editors photographs of your small installations, with brief statements as to the jobs being done. Never mind elaborate stories—the series will consist largely of pictures and captions. Of course accepted material will be paid for.

Possibly you are using, for a specific job, from 10 to 50 feet of roller conveyor; that's a small installation. Possibly a short run of overhead rail with chain block or hoist is doing a real job of handling; there's another example. Maybe you're making unusual use of jib cranes, or elevators, or trucks. Get the idea? Let's pool this kind of information for the benefit of industry. You can control the length of this series of articles—make it as long as you choose.

A PROBLEM IN COMPRESSOR REGULATION

A. L. BINGHAM
Ironton, Ohio

Automatic regulation of gas-compressor speed keeps plant pressure constant by pumping away surplus gas as produced.

IN ACCORDANCE with common practice, a byproduct coke plant, at which I formerly was employed, operated on the byproduct gas it manufactured. Because the amount of gas produced greatly exceeded the plant requirements, and there was no gas holder available, the surplus gas was pumped directly into a commercial gas line by means of a steam-driven compressor.

Because byproduct gas is manufactured at an irregular rate in a coke plant, a greater amount being produced when the oven is charged than during coking, it was necessary to vary the speed of the compressor to suit the fluctuating surplus gas supply. Gas consumption in the plant being relatively constant, the supply of surplus varied almost in proportion to the total amount produced.

The governor on the steam end of the compressor was of a type that could be set for any speed within its range by turning a speed screw. This adjustment either raised the governor ball, at the same time opening the steam valve to increase the speed, or vice versa, depending upon the direction in which the speed screw was turned.

Because the rate of flow of the gas to the compressor was changing constantly, the setting of the speed screw had to be changed so frequently that the entire time of an engineer was required to operate it. His duty was to adjust the speed screw so that the surplus gas was being pumped away at a rate that would keep the pressure in the plant line as nearly constant as possible. He determined the time for adjustment by watching a recording pressure meter, which measured the pressure in the plant line.

Obviously, this system of control was inefficient. It was impossible to keep the pressure in the plant line even close to constant because the pressure would rise or fall much faster than the speed could be changed. Also, the speed screw was so sensitive that the proper position had to be approximated. The position of the inking pen on the meter chart was caused to vary between ¼ and 2½ in. by this fluctuation in the plant pressure. The meter showed it to be at times above the set plant pressure and at other times below it. Occasionally the pressure drop was so rapid that a suction was created on the plant line, temporarily crippling plant gas supply.

When the plant pressure built up to a point beyond which it was dangerous to go, an automatic safety valve opened, allowing the gas to escape. The value of this dissipated gas was estimated to be between $50 and $70 daily. Coke-oven operation was handicapped seriously by the variation in its supply of gas.

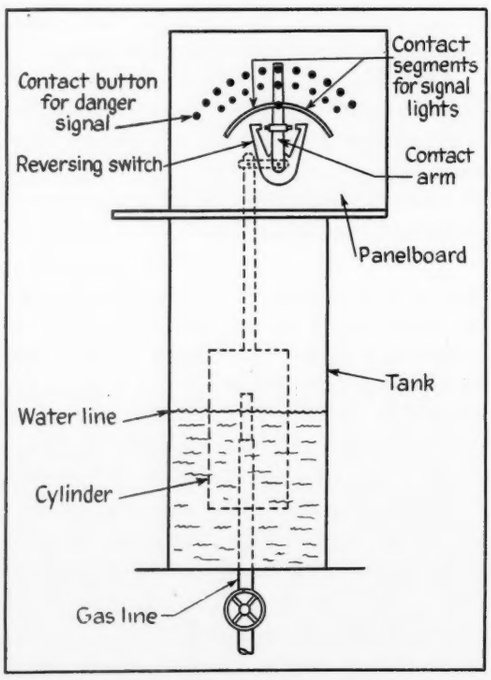


Fig. 1—Gas pressure in the plant line is indicated by the position of the contact arm on the panelboard, according to the height of the cylinder.

To overcome these objectionable features I constructed a regulator that controls the speed of the compressor automatically. It consists of three main parts: the pressure cylinder and control mechanism; the regulator proper; and the control station, magnetic clutch, and wiring.

The principal function of the pressure cylinder and control mechanism is to measure the plant line pressure and to close a corresponding circuit, which starts the motor of the regulator proper. This part of the regulator is made up of the following units as shown in Fig. 1: An open-end

tank containing water; a pressure cylinder; a rod and bell crank mechanism linking the cylinder to the contact arm; and a contact arm and panelboard mounted on the tank.

A 1-in. gas pipe, leading from the plant line, enters at the bottom of the tank and rises above the water line inside the cylinder. The gas pressure acts on the cylinder at this point, being sealed in the cylinder by the water.

Four sets of contact buttons arranged in two rows, two contact segments for signal lights, and a button for an alarm signal are mounted on the panel. Connection is obtained by three sliding contacts on the contact arm. The panel also carries a switch for reversing the motor when the pressure trend changes from upward to downward, or vice versa.

The signal lights indicate whether plant pressure is over or under its proper value. Set pressure occurs when the contact arm is in a vertical position in the center of the panel. When contact is made with the button for the alarm signal, a siren warns the operator of excessively low pressure.

The principal function of the regulator proper is to turn the speed screw the correct number of turns, and in the right direction, corresponding to the position of the contact arm. As indicated in Fig. 2, it consists essentially of a specially wound, reversible, ⅛-hp. d.c. motor; four regular sets of limit switches; four regular sets of cams; and two reset cam and limit-switch sets, all mounted on two parallel shafts; and a gear box. These parts are all assembled on a common baseplate.

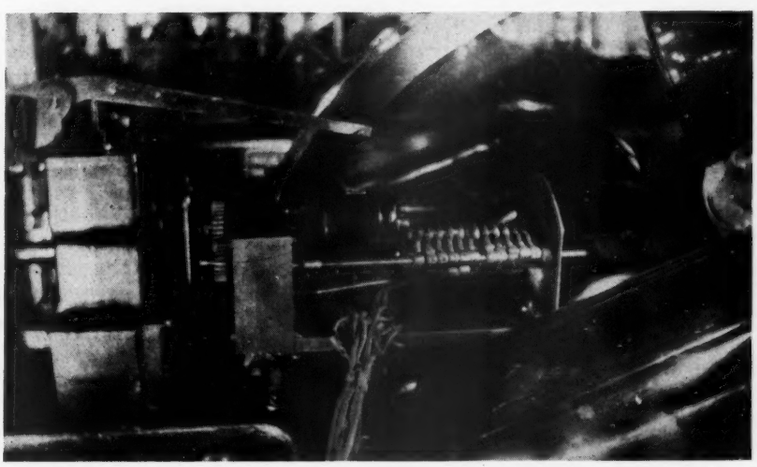
The motor is series wound, having two sets of field coils wound on the same core. This arrangement makes the motor reversible by making contact with one set of coils for forward rotation and the other set for reverse. The four sets of cams on the shafts operate the four sets of limit switches, each set of both cams and switches being made up of five units. Two additional cam and switch sets operate a reset circuit. Each shaft contains two regular sets of cams, and one set for resetting. The motor is direct connected to the gear box by means of a flexible coupling. The box contains the gearing for the speed screw and cam shaft drives. Its arrangement is such that the two cam shafts rotate in the same direction.

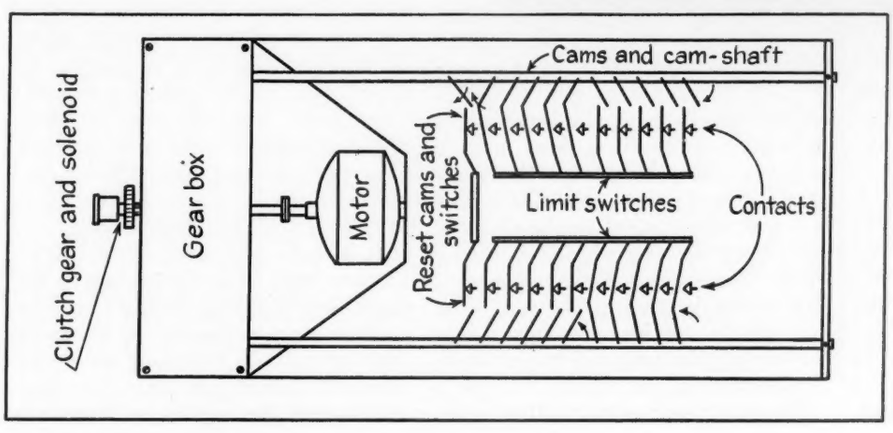
One set of cams on one shaft controls the speed in the forward direction above the set plant pressure, and a corresponding set on the other shaft controls the speed in the opposite direction. The two remaining sets, one on each shaft, control the speed in each direction when it is below the set pressure.

As the gas pressure steadily increases or decreases the cams open and close the limit switches of each set accordingly. When a cam has completed its travel it opens the limit switches of its set, stopping the regulator until the contact arm moves to another button. The cam action is such that the limit switches, corresponding to the buttons on each side of the button operating the regulator, are closed as soon as the regulator stops. This feature insures immediate regulation because the individual circuits operate the regulator motor one at a time as the contact arm closes them.

Cams are so designed and arranged on the two parallel shafts that, when the contact arm has traveled from vertical to the extreme position and the regulator has stopped, the parallel shafts have made about seven-eighths of a revolution, during which time the compressor has traveled to the highest or lowest speed that can be obtained unless the regulator is to be reset. The length of cam travel and hence the number of revolutions the speed screw is turned may be varied slightly between speed stops to suit conditions by changing the angular position of the cams on the parallel shafts by manipulating set screws on the cams. However, the total travel of the parallel shafts from neutral to the extreme positions must be maintained at seven-eighths of a revolution, or the reset circuit will not function.

The reset cams and switches are





Compressor speed is regulated by turning the speed screw controlling the governor setting on the steam end. The cams open the limit switches, stopping the motor when the speed screw has been rotated the amount indicated by the suction pressure.

Fig. 2 — Relation of all parts of the regulator proper is shown in this plan view.

actuated when a circuit is closed by pressing a clutch and reset button. These cams turn the regulator parallel cam shafts seven-eighths of a revolution before they break the circuit, after the regulator has been disengaged from the speed screw.

The control station, as shown in Fig. 3, consists of a metal box containing a double-pole push switch, a red and green signal light, a clutch and reset button, and two manipulating buttons. The double-pole push switch disconnects the regulator from the line when it is not in operation. The red and green signal lights burn when the regulator is being reset to accommodate an abnormal supply of surplus gas. They indicate the direction in which the regulator is running while being adjusted. The clutch and reset button operates a solenoid-type of magnetic clutch which disengages the regulator from the speed screw and closes one of the reset circuits as explained in the preceding paragraph. The manipulating buttons actuate the high- and low-pressure reset cams and limit switches on the regulator proper when the reset cams are in neutral position.

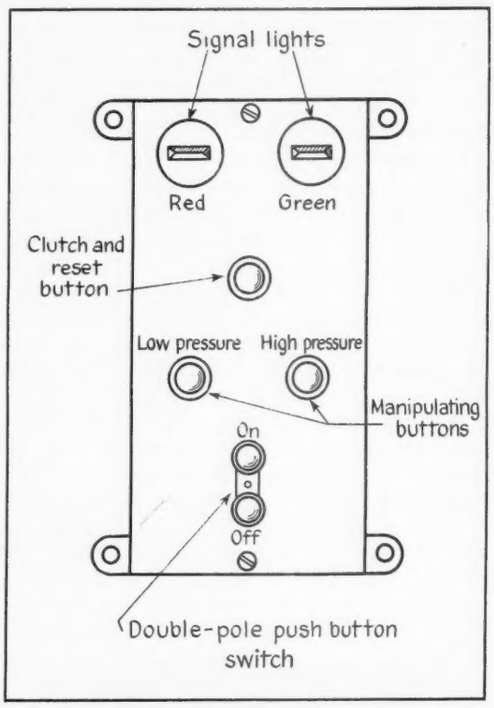


Fig. 3—Compressor and regulator control are centralized on a single panel.

Wiring, as shown in Fig. 4, is so arranged that, when the contact arm moves to the first button on the top row and to the right, current travels through the extreme front limit switch on the right-hand shaft, through the right-hand reverse switch, and then to the motor through one set of field coils and the armature, and finally to the negative side of the line in the control station.

One side of all limit switches in each set connects to a common wire which goes to the reverse switch. The other side of the limit switch is connected to the contact buttons on the panelboard.

The operation of the regulator is as follows: Assume plant pressure at its set value, the compressor running at normal speed, the regulator in neutral position, ready to operate the speed screw in either direction, and the contact arm on the panelboard in the central position.

A coke oven is charged with pulverized coal, generating a large volume of gas, causing the plant pressure to rise. The increased pressure raises the cylinder. This action causes the contact arm to travel to the first button on the top row to the right on the panel, making a connection that starts the flow of current to the motor through the first contact button and first limit switch of the front set on the right-hand shaft.

The motor starts to run in the direction that "open" the speed screw and causes the compressor to speed up before the cam rotates far enough to open the limit switch and stop the motor. This increase in speed tends to maintain the set pressure by pumping away the surplus of gas. But let us assume that the gas continues to be generated faster than this increase in speed can care for. In this case the cylinder is raised higher and the contact arm moves onto the next contact button, again raising the speed. This sequence continues as long as the pressure rises, increasing the compressor speed each time until the contact arm has reached the last button. All during these operations the green signal light has been indicating a pressure above the plant pressure. If the gas should continue to increase in pressure, it is necessary to reset the regulator.

Resetting is accomplished by pressing the clutch and reset button on the control station, which energizes the solenoid-type magnetic coil, shown in Fig. 5, disengaging the clutch gear from the speed screw and closing the circuit through the high-pressure reset limit switch thus turning the parallel shafts and cams seven-eighths of a revolution to their neutral position, where the cam opens the limit switch and stops the regulator. This contact opens the circuit through the contact arm at the same time. The pressure then is removed from the clutch and reset button, the clutch re-engages the speed screw, and the circuit is closed through the contact arm. The regulator is now reset.

The regulator now speeds up the compressor by rotating the speed screw an amount corresponding to the full seven-eighths of a revolution of the cams because all limit switches are closed in that direction, the contact arm still being on the last contact button. When the regulator has reached the last limit switch, if the gas pressure should hold up that long, it will come to a stop and must again be reset. However, this condition occurs only in rare instances because the high speed of the compressor usually lowers the pressure enough to start the contact arm toward neutral.

All this time the plant pressure has been maintained at, or very close to, the set pressure; consequently all surplus gas has been pumped into the gas line.

When conditions again approach normal the contact arm will reach neutral and stop, and the regulator should be returned to its original setting by pressing both the clutch and reset and the right-hand manipulating buttons. Closing the clutch and reset circuit will disengage the speed screw but will not start the regulator because the reset limit switch is open in the neutral position. Therefore, a separate circuit must be closed to start the regulator, which is accomplished by also pressing one of the manipulating buttons. Pressure is maintained on both buttons until a pointer on the parallel shafts indicates that the cams have been returned to their original position, when it is released. Now the plant pressure is at its correct value when the contact arm is in neutral position, as originally.

It is to be noted that at the instant the first cam of the front set on the right-hand shaft opens the circuit in that set when at the end of its travel, the first cam of the front set on the left-hand shaft closes the limit switches in its set, in readiness for

the time when the contact arm starts back. The other two sets of cams operate similarly when the contact arm is on one of their buttons.

When the contact arm starts back toward neutral the contacts of the reverse switch momentarily remain stationary, causing the right-hand contact to open and the left-hand contact to close, because the contacts are dragged along under a slight pressure by the contact arm. The middle sliding contact on the contact arm makes contact with the first button on the lower row of buttons, causing the motor to start in the reverse direction, until the first limit switch of the front set of the left shaft again opens. This procedure is continued until the regulator is back to neutral.

If for some reason, such as a hold-up or delay in charging ovens regularly, the gas pressure falls below the set value, the contact arm drops to the first button on the top row to the left and slows down the compressor, cutting down the amount of surplus gas being pumped and tending to hold the set pressure.

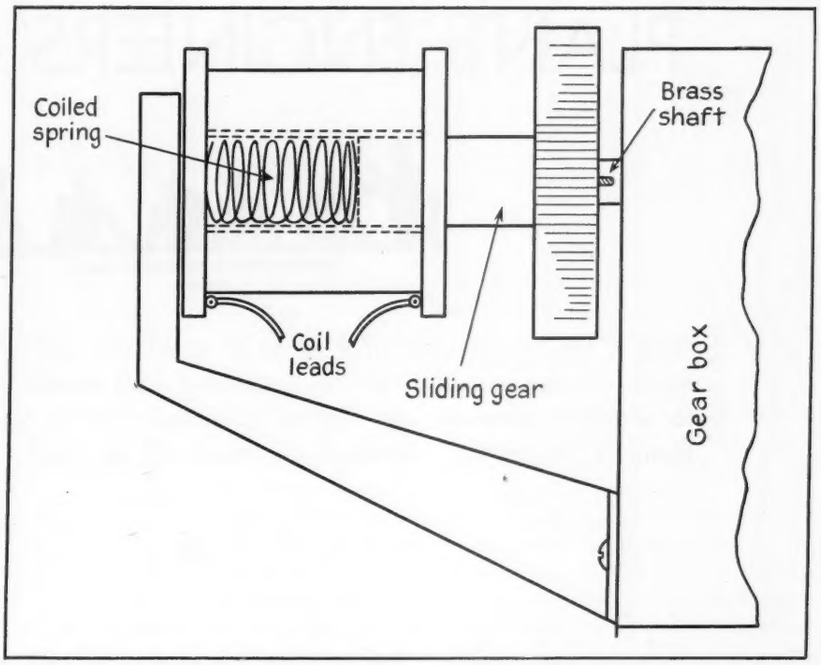


Fig. 5—When the solenoid coil is energized by pressing the clutch and reset button, the sliding gear is drawn into the plunger, disconnecting the speed screw from the regulator.

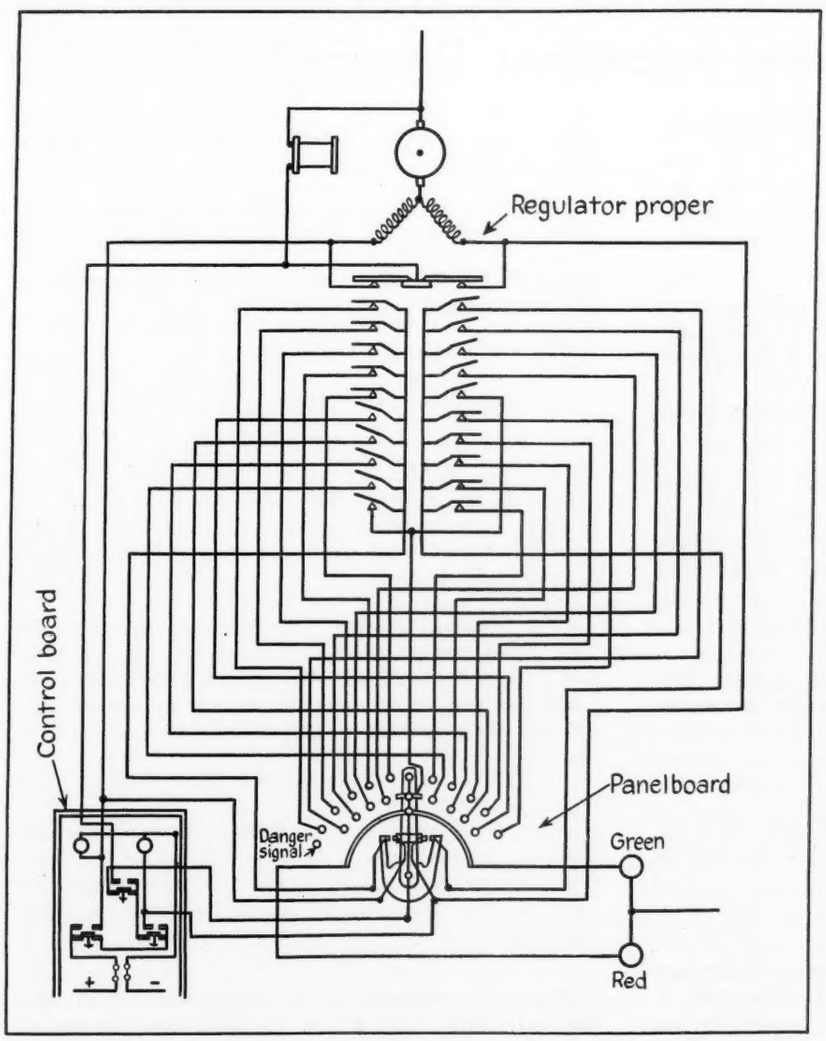


Fig. 4—It will be noted in this wiring diagram that the limit switches on each side of the position of the contact arm are closed, anticipating the movement of the contact arm in either direction.

The bottom contact on the contact arm now is connected with the red-light signal segment. If the pressure falls to a point where the contact arm reaches the button on the extreme left, a siren signal gives warning of the dangerously low pressure. Compressor speed is so low when this point is reached, that it is safer to stop the compressor than to reset the regulator.

When conditions again become normal the pressure starts to build up, and the contact arm connects with the lower row of buttons until it has come back to neutral, and again the plant pressure has been maintained.

It seldom has been necessary to reset for a higher pressure than can be regulated by the first speed setting because experience has shown the necessary speed range.

The regulator has been operating for more than two years with very satisfactory results. The pen on the recording meter chart seldom moves more than ¼ in. The device dispensed with the speed screw engineers (three were required for 24-hr. operation) and gave the safety valve a needed rest.

PLANT ENGINEERS' FORUM

Here is the twenty-third of a series of questions, each of which has at least two sides. A new question will be presented next month, and our readers' answers to previous questions also will be published. Write down your opinions and send them to the editor. Answers published will be paid for at an attractive rate.

Should the Maintenance Department Have a Separate Inspection Division?

As we join George Shipman and Frank Fulleger in this episode they are driving in Frank's new car to a plant some distance out of town, where they have arranged a tour of inspection. Frank is glad of the opportunity to discuss a bothersome phase of his work.

* * *

"Good idea, these trips, George. Get you away from the grind and the grief of your job. Give a fellow a chance to think things out without being interrupted."

"Sounds a little sour, Frank. What do you mean, grief? Anything special happen lately?"

"I'll say. Crane cable broke yesterday with a big load of castings. Lucky nobody was near it or our accident record would have been all shot. It does get my goat because it's the very thing I've been trying to avoid."

"Did they tie it on you?"

"They sure did. I caught it good and plenty. The boss said it wouldn't have happened if my inspection had been up to snuff."

"Don't you agree with him, Frank?"

"Yes, I do, George. But the trouble is I can't lay my finger on the guilty man under our present line-up of inspection."

"Why not, Frank?"

"Our men make their inspections between their regular repair jobs and installation work. The way it works out, it is very seldom that the same man inspects the same equipment twice in a row. Then they often skimp through inspection because they have a rush job waiting for them."

"But how about your inspection reports? They ought to show you just who reported that cable O. K."

"Well—er—I've been trying to keep down the clerical work and filing, and——"

"There's your answer, Frank."

"What and how, George?"

"It's the age of specialization, isn't it? Why not organize a separate inspection division with one good man responsible, inspection being the only job of the division? And as for records—you were so doggone economical there that you stuck your neck out a mile. No sympathy from me."

"I'm deflated, George. Been patting myself on the back about the good job I'm doing, and you show me that I haven't even reached first base. Here's the plant. Lucky for me—if we went any farther you might make me feel like a real flat tire."

* * *

As a result of this conversation we feel sure that Frank soon will have a definite solution of his problem. MAINTENANCE ENGINEERING *invites its readers to send in their ideas on the merits or demerits of the plan suggested.*

* * *

Is it practicable to isolate inspection in a division separate from the rest of the maintenance department?

(Answers to previous questions start on the following page)

READERS' ANSWERS

To Previous Questions

What Qualifications for a Maintenance Engineer?

(Question presented in the August issue)

EDUCATION and experience are essential qualifications for a job in any capacity. There is no excuse for ignorance today. All channels to knowledge along any specific line are wide open. The knowledge is available in the form of technical books and magazines which bring modern methods right to our desks. A new way to do a job is old the day after it has been done.

The maintenance engineer must have a good basic technical education, whether he obtains it in college or by sheer force of initiative. He must possess a background of experience sufficient to apply his technical training to practical problems. At one time I was asked the question: "Suppose two men applied for a job in the maintenance department, one of them having only a good technical training, and the other having only a great deal of experience. Which one would you employ?" My answer was: "If I needed two men, I would employ both. If I needed only one man, I would employ the one with a technical education and see that he obtained the necessary experience." Colleges do not turn out engineers; they turn out students who, if they possess the necessary initiative, some day will become engineers.

Personality also is an attribute valuable in every phase of life. The maintenance engineer must possess, above all things, self-control. I believe that this quality is personality of the highest order. The master of his temper surmounts all difficulties by keeping a cool head. When a man loses control of his temper, he also loses the respect of his organization and muddles his reasoning powers.

The maintenance engineer must have a good conception of economics. The decision rests with him whether a machine is obsolete or beyond repair. The result of his decision will either save or dissipate his plant's money.

He must possess the ability to select men and to place enough confidence in the men selected to permit them to do their job without undue interference.

C. C. HERMANN, *Plant Engineer*
John Deere Tractor Company
Waterloo, Iowa

TO HANDLE his job successfully the maintenance engineer must be a born manager and diplomat. He must be a man of wide experience, having a knowledge of everything that enters into the erection and operation of his plant. He also must know how to purchase, install, and repair machinery.

He should have at least a high-school education, supplemented by courses on the various trades involved in plant maintenance. A graduate of mechanical engineering would be preferred from a knowledge standpoint but, until maintenance engineering is recognized as a profession, the technical man probably would object to some of the maintenance work in the smaller plants. Until our educational institutions inaugurate a specialized course in plant maintenance, education alone will not make a maintenance engineer. Some of the large manufacturers are conducting classes of young men, picked from their workers and under the tutelage of their maintenance engineers, to develop their own maintenance men. Small plants cannot afford to conduct such classes and, therefore, are at a disadvantage.

In regard to personality the maintenance engineer must be a genius because he usually gets the blame for everything that goes wrong. He must take all complaints with a smile and secure the cooperation of all departments in the matter of shutting down equipment for repair. And last, but not least, he must be able to get the greatest amount of work out of his men in case of emergency repairs.

M. PETERSON
In Charge of Plant Maintenance
Western Electric Company
Emeryville, Calif.

QUALIFICATIONS that are most important in enabling the maintenance engineer to handle his job successfully are interest, tact, business ability, initiative, and mechanical ability. These attributes are not the only ones to be desired, or has every successful maintenance engineer all of these qualifications but, if any are lacking, an overabundance of other qualifications should make up for the deficiency.

Interest, perhaps, is the only qualification that is absolutely essential. The advance of maintenance from a haphazard, "poor relation" type of existence to one of the most far-sighted and well-managed divisions of plant management can be attributed mainly to the interest of maintenance engineers in their work. Tact is necessary because the maintenance engineer comes into contact with practically everyone in the plant. In times of stress and emergency many people "fly off the handle" unless carefully handled. In most cases the maintenance engineer runs his department with little direction from his superiors—as a business within a business. In order to perform this function he must have real business ability. Devising ways and means to perform the maintenance job economically without interfering with production calls for initiative—and plenty of it. Hand in hand with initiative should come mechanical ability—necessary to insure the practical value of the maintenance engineer's actions.

All qualifications previously discussed require development by experience, which should be varied because the maintenance engineer's duties are varied. In addition to practical mechanical experience the engineer should have had experience in manufacturing. Such

experience is essential to an understanding of the methods and needs of the productive departments. It is difficult to judge how much experience the engineer should have because the necessary amount depends on the type and size of his plant and the character of the engineer. As a rule he should be a graduate engineer because such training provides a better foundation for executive work than most mechanics can acquire through practical work alone.

BERNARD SHEREFF, *Engineer*
Standards Department, American Hard Rubber Company
College Point, L. I.

THE MAINTENANCE engineer should have a background of experience. He should use the present to sift out the chaff of old practices, retaining that which is fundamental in building for the future. Experience with a great variety of equipment offers to the man with an analytical mind the opportunity to obtain a broad practical education. The maintenance engineer should be able to develop a specialist from among his men for each phase of the work of his department.

Personality consists principally in giving everyone the courteous consideration which is due him. The outstanding maintenance engineer always has accumulated a good education either by hard knocks or in school.

Natural mechanical ability assists the maintenance engineer in his work. The ability to observe apparently insignificant details should be another of his characteristics. This spirit of studied observation should be communicated to the entire maintenance organization. Cooperation should be extended to other departments, and a reciprocal treatment expected in return.

J. ELMER HOUSLEY, *Electrical Superintendent*
Aluminum Company of America
Alcoa, Tenn.

Initiative or Apathy?

(Question presented in the June issue)

THIS MONTH'S problem indeed has two sides. The answer to the question—whether the maintenance engineer should initiate proposals for the purchase of new equipment or modification of existing equipment—will differ in various plants according to the amount of responsibility delegated to the maintenance engineer in each case.

In some plants the maintenance engineer writes the requisitions for proposed equipment or material. Each executive under whose scrutiny the requisitions pass—the superintendent, the plant manager, or the purchasing agent—cuts them down and alters them so that, when the equipment or material is received, it frequently is entirely different from that which the maintenance engineer requisitioned. It is probable that an "initiative" man, placed in such a plant in the capacity of maintenance engineer, soon would become disgusted and either resign or slump into apathy.

I have been employed in plants in which all suggestions were treated with courtesy and examined by all departments concerned. There are other plants in which all suggestions are supposed to come from the management, no others being considered. There is no alternative, when employed in the latter type of plant, but to execute orders as received without comment.

I believe that a maintenance engineer's proposals would receive more consideration from the management if such proposals were studied carefully from every angle and then placed in writing. Often projects do not sound as well after they have been written and re-read.

GRADY H. EMERSON, *Chief Electrician*
Reed Brothers Stone Company
Birmingham, Ala.

THE NATURE of an alert maintenance engineer is such that he is striving constantly to improve his plant in order to reduce the operating cost. Such a nature necessarily entails initiative.

There are two factors to take into consideration when buying new equipment or rebuilding old. They are to know the service required of a machine and the service rendered to the machine. Knowing these two factors by nature of his job, the maintenance engineer is the most logical person to make purchase recommendations. He will find that, if he does not take the initiative, someone else will, and equipment will be wished on him which may bring with it a lot of grief.

Highly complicated machinery may require specifications drawn by a specialist in that particular line, but the maintenance engineer should be consulted to obtain his ideas and to sell the equipment to him. Such consultation will make him responsible as a party to the purchase and, therefore, he will be more willing to assume the responsibility for its maintenance.

L. H. DICKELMAN, *Building Superintendent*
Ed. Schusler & Company, Inc.
Milwaukee, Wis.

THERE are so few real live wires possessing initiative in these days of slack conditions that a maintenance head with enough faith in his ability to propose concrete plans for the actual improvement of operating conditions should be a valuable asset to any industrial plant.

A real example of this sort of initiative on the part of our maintenance man, who brought home the bacon and paved the way for further heed to his suggestions, remains fresh in my memory. He insisted on the adoption of V-belts on some troublesome transmission drives, which materially cut our maintenance and power costs when installed.

I fully believe that men in responsible positions should take the initiative and, to encourage them, we should be quick to heed their suggestions concerning purchase or replacement of equipment.

The maintenance man is in an especially vital position with reference to what sort of equipment should be purchased to replace that which has given him a lot of trouble.

CHARLES H. WILLEY
Superintendent of Manufacture
Hoyt Electrical Instrument Works
Penacook, N. H.

I BELIEVE that the man in charge of maintenance should take the initiative. Who knows better than the men in the maintenance department how much trouble a piece of equipment is giving or what modifications could be made to it to cut the maintenance costs? More important than savings in maintenance costs is the smooth, continuous operation of equipment during pro-

duction schedules. This result can be obtained only by hunting out systematically the weak points of the equipment and modifying it accordingly.

When the maintenance department finds a piece of equipment so nearly worn out that the costs of reconditioning it amounts to almost as much as a new unit, it would be better to buy a new machine than to recondition it because the re-vamped equipment is more likely to break down.

The management must be shown in black and white just what the proposed equipment will accomplish. A new machine may save enough money in a year to pay for itself in increased production, lower maintenance costs, and less fatigue of the operator.

J. CONRAD WATSON, *Master Mechanic*
Franklin Pottery, Lansdale, Pa.

Who Orders Repair Shutdowns?

(Question presented in the May issue)

I BELIEVE that the plant engineer should be absolutely responsible for this order, provided that he uses due intelligence and cooperates with the production department. In case of emergency or danger, his word should be final. When goods have been promised for definite shipment dates and it is possible to postpone the shutdown without serious danger, the plant engineer should favor the production department.

When there is an argument over the shutting down of equipment that might create a hazard, and the production department insists on operating it, the plant engineer should go directly to the owner of the business and waive all responsibility unless his order is carried out.

When a man is put in charge of maintaining equipment, he also should have the authority to state when and under what conditions such apparatus should be operated. K. D. HAMILTON, *Mechanical Department*
Geo. E. Keith Company
Campello, Brockton, Mass.

Should Maintenance Engineers Attend Conventions?

(Question presented in the April issue)

VOTE "Yes," for that is just as important a part of one's training as reading this journal. Plant, mill, and factory owners can be assured of large returns on the expense incurred. Consider the personal contact with the men in charge of the equipment on display and the wealth of information on their products that is ours for the asking.

There is where we find the real answer to the obsolescence problem. Many of us hesitate to write and ask for information on equipment that we are interested in, sometimes because we are not sure we shall buy, and sometimes because we don't want a salesman following up the letter before we have decided for ourselves how much we are interested. The convention, with its exhibitors, takes care of all that. We gather as much information and as many catalogs as we desire and make a lot of friends who may be of some help to us in the future.

The engineering sessions with their discussion give us the chance to see other engineers in the flesh and hear their voices and become imbued with their personality, and we feel more important to our concerns when we return home. CHAS. H. WILLEY
Assistant Plant Superintendent, Hoyt Electrical Works
Pennacook, N. H.

To Whom Should the Maintenance Department Report?

(Question presented in the March issue)

THE head of the maintenance department reports to the plant manager, but part of his department reports to the production manager.

The production manager's chief interest is to have the highest output at the lowest production cost. The plant manager's interest is also the greatest output, but at the lowest initial and overhead cost.

Here is where the cleaving of the maintenance work occurs: The maintenance crew, which is headed by the foreman, is subject to the production manager in regard to breakdowns. If a production machine breaks down, there is no question that it must be fixed, and fixed in a hurry. A call in the machine shop, and a rescue man is on the job; and the needed spare parts, which are in stock in any well planned plant, can be installed at once. From the kinds of breakdowns the production manager can determine which repair part departments to stock up, and which to work down. The pulse of any industrial undertaking is the flow of undisturbed production. As the production manager is in charge, he knows best what to do so that the flow remains undisturbed.

However, if entire machines have to be replaced, that job belongs to the maintenance engineer. It is he who specifies and turns the requisition over to the plant manager, working with the production manager.

Suppose we have a series of factories. Each plant has its own repair shop. One maintenance engineer, however, may be in charge of two or more plants.

All requisitions concerning the purchasing of new or spare parts, relating to production machinery and buildings, but not production materials, collect in the maintenance engineer's office and receive his O.K. It is he who knows which other parts from different sources may be used. If a change in the design of a machine is necessary, he can intelligently take care of it either through his own department or the engineering department. Requests, coming from different departments, thus are simplified and reported to the plant manager.

In brief, my opinion is this: The maintenance foreman who takes care of the occurring breakdowns is subject directly to the production manager and indirectly to the maintenance engineer. Through this arrangement the maintenance engineer is not bothered with too much detail work and is better able to collect enough data so that he may give to the plant manager, at any time, a clear picture of the plant's condition.

C. B. SCHAFER, *Mechanical Engineer*
Research Department
Libbey-Owens-Ford Glass Company
East Toledo, Ohio.

CONTROL OF SYNCHRONOUS MOTOR PUMP DRIVES

R. C. ALLEN
General Engineering Department
Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

IN SELECTING the synchronous motor for a centrifugal-pump drive, it is necessary not only to determine the normal and maximum horsepower requirements of the pump, but also to determine whether the motor can be synchronized under the load conditions that exist at the time the motor reaches the pull-in point, that is, 95 per cent of full-load speed. With the pump discharge valve open, a condition termed "starting loaded," the motor must develop nearly 100 per cent torque to handle the pump load at pull-in speed. This is true even if the check valve is used to prevent a return flow of the water. When the motor starts unloaded, with the discharge valve closed, the load torque at pull-in speed is only about 50 per cent of full-load torque.

The starter for a synchronous motor is very similar, except for synchronizing provisions, to the squirrel-cage motor type of starter. In fact the self-starting synchronous motor has a squirrel-cage winding in the pole faces, and the motor starting characteristics during the accelerating period are essentially the same as those of squirrel-cage motors. At the time of pull-in, or more accurately, synchronizing, the motor fields are excited from a d.c. source and the motor rotor, with its driven load, jumps almost instantly from the 95 per cent induction-motor or pull-in speed to the synchronous speed.

Starters are of either the full-voltage or reduced-voltage type.

The full-voltage starter connects the motor directly to the power line; after maximum speed as an induction motor has been reached, the field is applied.

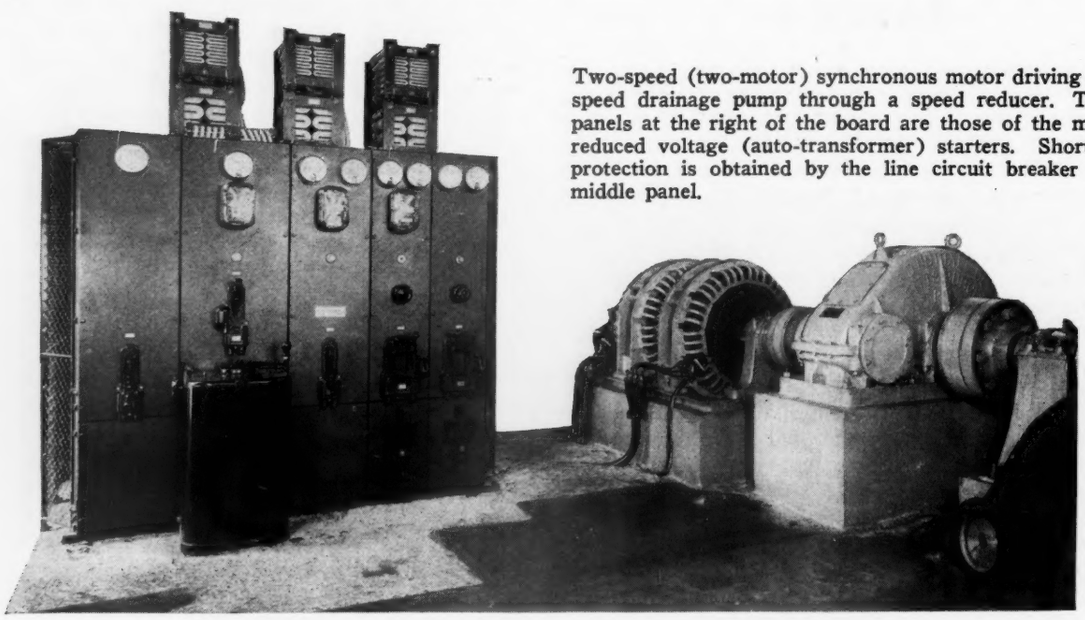
The reduced-voltage starter connects the motor to a source of reduced voltage, to limit the starting current drawn from the line, and then transfers the motor to full voltage when the motor has reached maximum reduced-voltage speed. The field is energized to synchronize the motor, or pull it into step, after full voltage is applied and the motor has reached 95 per cent speed. For drives with low pull-in torque, like generator sets, the motor can be synchronized on tap voltage, but standard starters are seldom modified to obtain this sequence.

Starting operations can be accomplished either by manual or by magnetic starters.

Manual starters, as the name indicates, are operated by hand. Magnetic starters can be operated by hand; by pushbutton, or other master control, designated "hand control"; or automatically operated by a float switch or similar device, designated "full automatic control."

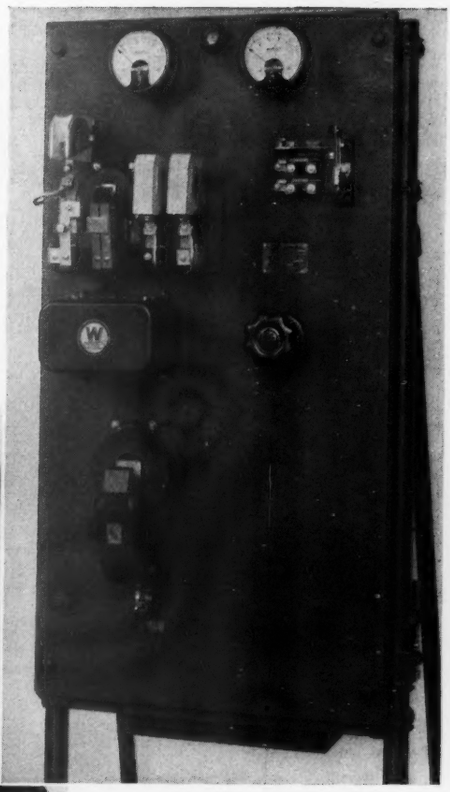
Reduced-voltage starting can be obtained by auto-transformer, by reactor, or by double winding motor.

The auto-transformer gives the highest torque for the line kva. but requires, except for complicated switching, that the main circuit must be opened when transferring the motor from tap voltage to full voltage. This is called "open circuit transition." This tends to cause a current surge and is, therefore, generally utilized only for the smaller ratings.



Two-speed (two-motor) synchronous motor driving a slow-speed drainage pump through a speed reducer. The two panels at the right of the board are those of the manually reduced voltage (auto-transformer) starters. Short-circuit protection is obtained by the line circuit breaker on the middle panel.

What items are to be considered in the application of the synchronous motor to pump drive? — What type of control is most satisfactory? — Does complexity of operation outweigh the advantages of increased efficiency, better power factor?



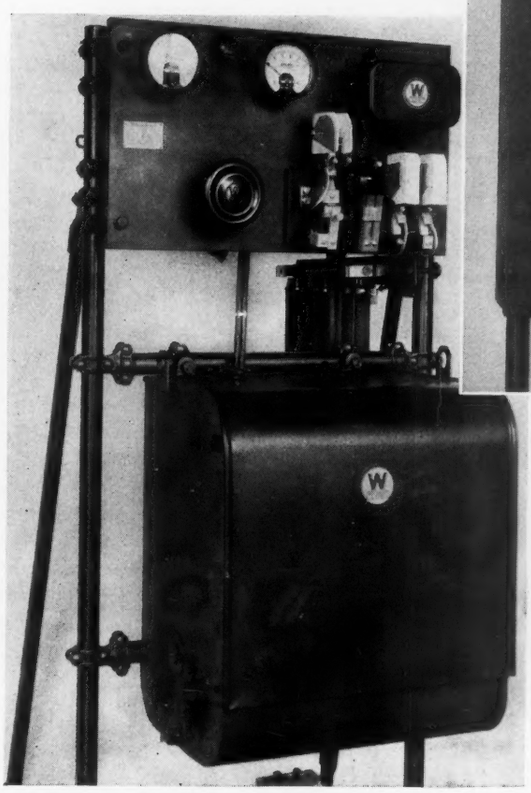
Full-voltage starter of the high-voltage type. An oil-immersed contactor is on the back of the board.

Taps on the auto-transformer allow for selecting the starting voltage.

In reactor starting, opening the line connection is not necessary because the reactor can be shorted at the time of transfer to full voltage. This is designated as "closed circuit transition." Reactor starting has the additional advantage in pump application, in that the drop through the reactor, which is connected in series with the motor, reduces as the motor comes up in speed, with consequent increase in motor torque.

When the double-winding motor is used, one-half of the motor winding is connected to the line first. This gives, in starting current and torque, about the equivalent of an 80 per cent auto tap.

Synchronizing is accomplished in all of the preceding cases after the motor reaches 95 per cent speed by exciting the field from a d.c. source. A reduced-voltage starter connects the auto-transformer or reactor to the line voltage and the motor to the reduced-voltage tap. After a time interval of 10 to 15 seconds, to allow the motor to reach maximum tap-voltage speed, the motor is transferred to full voltage, and the auto-transformer is disconnected. After another time interval, 3 to 5 seconds, when the motor has reached pull-in speed, the field is applied. These steps are governed by a definite, adjustable time device.



Synchronous motor starter using modified squirrel-cage hand-operated compensation and magnetic field switch.

The field can be applied by the field-frequency method; but for many applications, particularly for centrifugal pumps starting loaded, the definite time method using an a.c. contactor-operated field switch gives the most reliable operation, because the field is then positively applied without regard to variations in line or load conditions.

For hand-operated manual starters the correct timing is determined by the operator by observing the meters. As the motor accelerates to tap voltage speed, the current, shown by the ammeter, drops to a steady state, thus indicating the correct time to transfer to full voltage.

The proper time to close the field switch is indicated by the field ammeter's showing a minimum swinging of the induced alternating current.

Manual starters are generally of the reduced-voltage type using hand-operated circuit breakers. The field switch is frequently arranged to operate automatically so that starting a synchronous motor, as far as the operator is concerned, is as simple as starting a squirrel-cage motor.

If the motor fields are excited from a d.c. bus at constant voltage, a motor field rheostat is needed to adjust the excitation and so to obtain the correct motor power factor. If, however, the motor has a direct-connected exciter, or has its own m.g. set, the excitation voltage, and consequently the motor excitation and power factor, can be adjusted by the exciter rheostat. A motor field rheostat can be used also, but if the necessary control can be obtained from the exciter the most efficient operation will be obtained. The excitation normally should not be reduced below the rating given on the motor nameplate. This excitation will maintain the pull-out torque in case of low voltage, and loads below full load will then be able to

operate with more leading current.

Motors are designed in general to withstand the shock of full-voltage starting, and the pumps usually have sufficient rigidity to withstand the resulting torques of the motor. Full-voltage starting therefore can be used; but high starting currents may cause a line drop that will result in objectionable light flicker.

Generally, full-voltage starters are operated magnetically, requiring only a field switch and a line contactor or an electrically operated circuit breaker for connecting the motor to the line. The starting current is naturally higher than that which occurs with reduced-voltage starting; but a thermal-type overload relay permits a low setting for normal overload tripping.

Full-voltage starting is standard for the low-speed motors, driving compressors and like, for the current inrush is essentially as low as that taken by the high-speed motors using reduced-voltage starting. In large power systems there is generally ample capacity for starting most pump motors by the full-voltage method, particularly if the lighting load is not taken from the power-load transformers.

For centrifugal pumps or blower drives, there is available a synchronous motor employing full-voltage starting. This motor combines the high starting torque per kva. of the auto-transformer type of starter with the desirable accelerating characteristics of the reactor method, but retains the simplicity of full-voltage starting.

All starters should have protection at least against low voltage, overload, field failure, and single-phase operation.

There are two types of low-voltage protection, namely, "low-voltage protection," and "low-voltage release."

Low-voltage protection disconnects the unit when the voltage reaches the low setting of the relay, and requires a restart by the operator. For full automatic control—operation from a float or pressure switch—low-voltage release is used. This allows the motor to restart automatically upon return of voltage.

Overload protection can be obtained by thermal overload relay, induction-type overload relay, or dashpot overload trip.

The thermal type is used for normal overload protection, and follows directly the heating of the motor. The induction or meter type is more responsive to short-circuit conditions and is used particularly with circuit-breaker control. The dashpot type is incorporated in the direct trip for the circuit-breaker type of starter.

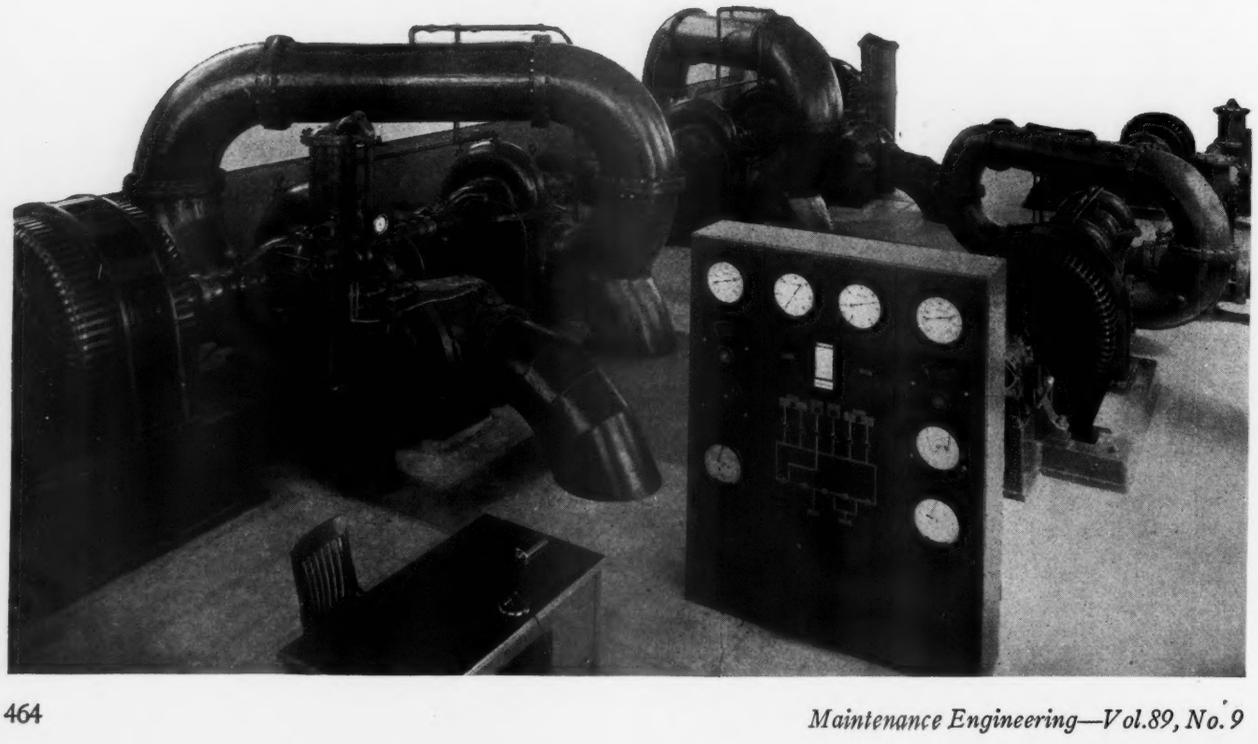
There should also be protection against a possible short circuit due to a breakdown in the motor, control, or line connections. This is handled best by the circuit breaker in the feeder line, with quick-acting overload trips that will act before the control overload trip. Contactors are designed and selected to handle the short-circuit (locked) current of the connected motor but are not selected to act as circuit breakers.

Special relays for protection against field failure and single-phase operation can be added; but they are hardly necessary, because the high current resulting from this unusual operation will quickly cause the motor overloads to trip.

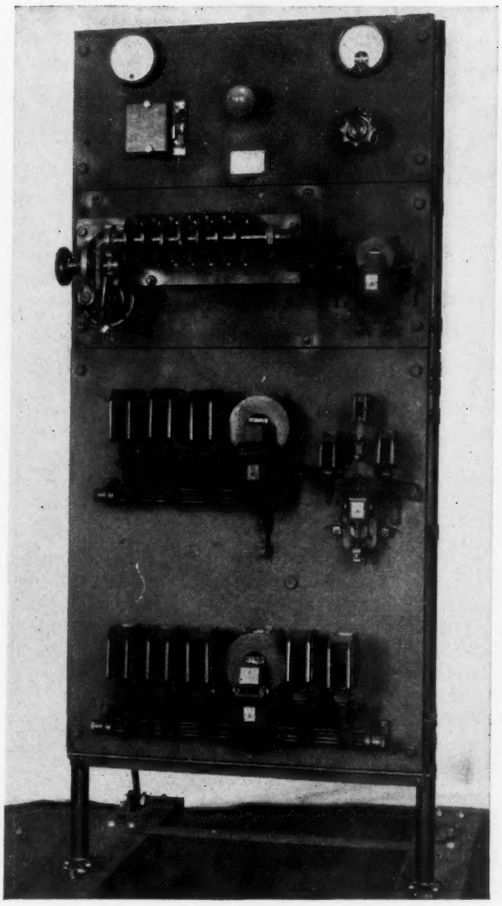
Resynchronizing upon failure of voltage is necessary with full automatic control, for, in case of voltage failure, the motor must restart and synchronize just as when starting under normal conditions. This is inherent in the standard low-voltage release control, where the voltage failure affects operation the same as pressing the "stop" button, and the return of voltage the same as pushing the "start" button. An additional relay for resynchronizing upon motor pulling out of step is sometimes advocated, but except for very special applications, a motor pulled out of step by its load is incorrectly applied.

There are many variations in starters. High-voltage magnetic starters (2,200 volts and above) use oil-immersed contactors in tanks mounted on the rear of the panel. Larger sizes require separate mounting of each contactor and operating mechanism.

For small synchronous motors (below 100 hp.) a modification of a squirrel-cage compensator is available



Synchronous motors driving centrifugal pumps at N. Hollywood Pumping Station, Los Angeles. Master control board shown in foreground.



Reduced-voltage magnetic starter using auto-transformer. Overload protection is of the thermal type. The motor-operated drum (cover removed) governs the timing of the starting cycle.

which includes a hand- or magnetically operated field switch.

Although two-speed synchronous motors are available, their application is limited by their fixed speeds and by economic considerations. For variable capacity in pumping, it is customary to secure the desired variation by changing the number of pumps operating, taking advantage of the natural characteristics of the centrifugal pump. Finer capacity adjustment can be secured by a slipring, adjustable-speed motor if necessary.

Variations in speed can be accomplished either by two separate motors on the same shaft, for low-speed units, whereby standard speeds can be secured; or by reconnecting the armature and field windings, making a 50 per cent speed reduction possible.

For the control of the two motors, where two-motor speed variation is employed, essentially two independent motor starters electrically or mechanically interlocked are necessary to prevent false operation.

One important requirement for satisfactory operation of any control is the maintenance of perfect operating condition. The control should be protected from dirt and dust. For very dusty places, the unit should be installed in a separate room or inclosed in a cabinet. Ample ventilation or radiation must be provided. Contacts improperly adjusted or maintained result in heating when running, and in injurious arcing when opening, or even rebounding and welding on closing. Contactors should be designed or adjusted so that the arcing is handled by the tip of the contactor or by auxiliary contacts not handling the running current. It is desirable to operate a contactor once or twice a day to wipe it free of dust or of the oxide film that may have formed on the contact surfaces because of heating from overload currents.

Circuit breakers should be inspected periodically to maintain the contact surfaces. Oil should be changed, or at least filtered, every six months.

Synchronous motors are as simple to operate as corresponding squirrel-cage motors, when properly selected and maintained. They are particularly applicable where power-factor correction is desired, or where efficiency is of prime importance.

■

Contact Alignment

SOME maintenance foremen and superintendents may question the importance of contact alignment; yet often it is the lack of correct alignment which makes new circuit-breakers, compensators, and switches a constant source of trouble after the first repairs on their contacts.

In making repairs on equipment with two or more contact fingers, it should be borne in mind that all contacts should make and break the circuit at the same instant. If they do not, a heavy arc is concentrated on one or two contacts, with diminished contact surface and high contact resistance, which causes excessive heating and finally a "frozen" or open contact.

Following is a method of adjusting for correct contact surface and time of break that has proven very satisfactory at our plant:

First disconnect any quick-break mechanism, install a full set of new contacts, shimming, filing or bending at contact supports until all contact fingers make contact at the same instant, and then make a final check as to the instant of contact or break. This may be done with two voltmeters, or two lamps, each connected in series with a battery or light line across a pair of contacts.

By watching the meters or lamps closely, and closing or opening the contacts very slowly, one may see which pair of contacts leads or lags, and make adjustment good enough for practical purposes. Such time adjustment will give service equal to the original set of contacts, but they still must be adjusted for contact surface as formerly.

In repairing the used or burnt contacts, one should match full sets of contacts according to wear or depth of burns, and grind down with a fine wheel, using an adjustable jig so that all contacts of any one set may be ground to a uniform size. This jig can be made at a small cost by your machinist to meet your particular needs.

On three-phase oil circuit breakers there are usually two stationary and two movable contacts per phase. Of the two stationary contacts, one is connected to the in-coming and the other to the out-going line of a phase, while the movable contacts are electrically connected together. In this case it is necessary to get an alignment between movable contacts and the in-coming and out-going contacts. The next operation is to get the correct alignment between phases. Simple series lamp circuits will accomplish these results.

There are at least two contact fingers per pillar unit and movable contact on a circuit breaker. These fingers must be adjusted to the best of one's ability with feeler gage and eyesight.

On the start and motor sides of a compensator both lamps will burn because of the feed-back through motor and compensator coils, but there is usually enough difference in brilliancy for the successful use of lamps. If not, it will be necessary to disconnect a few contact leads.

Louisville, Ky. J. R. ESTES.

QUESTIONS and ANSWERS

What Causes Unbalance in Phases of Motor

Two of our 440-volt, three-phase, squirrel-cage motors show an unbalanced running current when an ammeter is put in each leg. On the bench, the resistance of all phases, measured from lead to star, is identical. Also, the current taken by each phase, with the rotor removed, is the same. What causes this unbalance? Another question. What is the surest way of detecting a reversed coil in a three-phase stator? I have not had much success with the compass method, as the other coils of the same group more than offset the opposite polarity of the reversed coil; hence, the needle does not reverse.

Lomita, Calif. C. H. F.

■

Soldering Aluminum Alloys

Can any readers give me some information regarding the materials and methods used in soldering some of the modern aluminum alloys? F. I. C.

Courtdale, Pa.

■

Does Repeated Melting Injure Babbitt?

When we rebabbitt bearings the usual procedure is to melt the old metal out of the shell—sometimes it is chipped out—and use it over again, after adding whatever amount of new metal is required for the job. Sometimes we do not add any new metal. I am concerned here over the fact that a considerable portion of our babbitt has been melted and used repeatedly, and am wondering if such treatment is likely to cause any deterioration through oxidation or loss of some of the constituents. I should like to know how often a given amount of babbitt can be melted and used without injuring its qualities, providing, of course, that it is not heated to an excessive temperature. L. H. C.

Detroit, Mich.

Please submit answers promptly. We expect to publish no answers later than the second issue following the appearance of the question. Selection will be made on the basis of quality, but answers first received have the best chance of being used.

Why Did Grinding Stator Cause Trouble?

We recently had a 300-hp., 2,200-volt, three-phase, 25-cycle, 1,500-r.p.m., squirrel-cage motor in which the rotor pulled hard against the bearing opposite the pulley end. Sleeve bearings were used. The stator had 72 slots and the winding was connected single-circuit star. The rotor had 58 bars. The stator punchings were continuous rings, and the bore had been ground to size. A new stator core, not ground, eliminated the trouble. We considered it to be due to leakage flux crossing the air gap, in which the reluctance of the path was considerably less in some places than in others, due to the grinding of the stator. Will readers who have had a similar trouble please give their views on what they consider to be the cause? F. E. S.

St. Catharines, Ontario, Canada.

BECAUSE a new stator cured the trouble it would seem likely that the stator alone was to blame, rather than a poorly centered shaft. Unbalancing of the magnetic circuit is the most likely explanation of the action described.

The fact that the stator was ground leads me to be suspicious of its trueness. Grinding is usually a last resort employed to correct some defect in design or manufacture, and frequently becomes a compromise piece of work in correcting a defective air gap, because of the small amount of stock that can be removed without weakening the slot structure.

There may be two reasons for the excessive end thrust. One is that the bore may have been tapered. The other reason is that the laminations may have been burred over by too high grinding pressure, or by the use of a poor wheel. Burring of the laminations would tend to make them practically a solid piece of iron in places, and if the entire surface were not uniform it would cause an unbalance in the reluctance of the magnetic path, with consequent distortion of the magnetic circuit.

Chief Electrician B. C. ALGEO, JR.
Kalamazoo Vegetable Parchment Company
Kalamazoo, Mich.

PROBABLY the end thrust was caused by a misplaced bearing, rather than by the grinding of the stator bore. An uneven air gap would cause a radial pull, trying to force the rotor over against the stator, but would not tend to displace the rotor in an axial direction.

Unless prevented from doing so, the rotor of an induction motor will pull over to the center of the magnetic field, so that the center line of the rotor core corresponds with the center line of the stator core. The rotor then will float freely in this position while the motor is running. This effect follows from the effort of the magnetic field to make the length of the air path of the flux lines passing between the stator and the rotor as short as possible.

If one bearing were moved in too far by reason of incorrect assembly, the inner end of the bearing shell would push against the thrust collar on the shaft and thus move the whole rotor away from its central position. At the same time the force of the magnetic field would cause the rotor to push back against the bearing, in an attempt to regain its central position, thus causing the objectionable end thrust.

It is evident that the same effect would be obtained if the bearings were in their proper position, but the stator core were pressed too far into the motor frame.

Disappearance of the thrust after the motor was dismantled and fitted with a new stator core can probably be ascribed to more careful assembly.

G. E. CREED.

Hamilton, Ontario, Canada.

Methods of Cleaning Building Sandstone

Can readers tell me whether there are any practical methods, other than sandblasting, of cleaning building sandstone?

Lansing, Mich. **F. E.**

CLEANING sandstone, cement, or bedford stone is a difficult matter, after the stone has been exposed to smoke and the elements for several years. Sandblasting is effective, but often difficult to employ, and has the disadvantage that material is removed from the stone.

I have used a liquid known as Lingerwet, which is sold at most paint stores. It is applied with a brush, and then the surface is smoothed down with sandpaper. This procedure is inexpensive, but only for small surfaces.

A more practical way to clean large areas of stone is to apply a very thin coat of cement paint and then sandpaper the surface. The ordinary cement paint obtained from commercial sources must be reduced with water before application. This method adds material to the surface of the stone, instead of removing it. In the case of relief work the depressions cannot be sanded very easily; however, they are clean because of the paint coating.

Waterloo, Iowa. C. C. HERMANN.

■

What Causes Spark on Ground Test?

When testing for grounds on a three-wire, a.c., 110/220-volt light panel with a test lamp, I often obtain a hot spark when the busbars are touched, but the lamp does not light nor will a voltmeter give any reading. Does this spark indicate a ground with a high-tension wire, or other abnormal condition? If not, what causes it? R. S. T.

Worcester, Mass.

SPARKS mentioned by R.S.T. are, I think, due to condenser action and not a high-tension ground, as evidenced by the fact that he does not obtain a reading on the voltmeter. The condenser action is probably due to the fact that a considerable part, perhaps all, of the wiring is in conduit or other metal covering. The wire, which carries current and is insulated from the conduit, becomes in effect one plate of a condenser; the conduit takes on a charge opposite in sign to that on the wire, and forms the other plate. Although the alternating current tends to limit the amount of the charge, there is enough at any instant to cause a small spark.

Chief Engineer H. R. WILLIAMS.
Ash Grove Lime & Portland Cement Company
Chanute, Kan.

WE HAVE encountered similar trouble on a circuit that feeds a pump house on the river, from the charge induced in it by a 140,000-volt line that runs parallel to it. It is almost impossible to test this line except with a voltmeter or lamp, because we always get a spark from all lines, whether live or dead.

It is thus possible that in the present instance the spark is caused by the charge induced by some nearby high-tension apparatus. B. C. ALGEO, JR.

Chief Electrician
Kalamazoo Vegetable Parchment Company
Kalamazoo, Mich.

■ ■ ■

ONE SURE THING

From *The Business Week*, August 19, 1931

WE HAVE several times expressed our doubt that this depression is due to any serious or widespread internal defects or weaknesses in American business, and have accorded first importance in our diagnosis to certain external factors of financial and governmental policy. Business needs a turkish bath, a rubdown and strenuous osteopathic treatment of several sorts to restore its circulation and straighten out the cricks in its back that come from imprisonment in a political straightjacket and a cramped credit position unconscionably prolonged.

But if there is any prescription for the ills of industry, transient or chronic, to be taken internally, the one medicine we can enthusiastically endorse is modernization of equipment. Most industrial tonics are defective or dangerous in one way or another, the most serious faults being that they may prematurely expand the capacity of the industry or raise the blood pressure on employment so as to put somebody out of business and many out of work.

But obsolescence is a disease to which industry has a chronic predisposition, a kind of hardening of the arteries hastened by high and fast living; and the modernization tonic, prescribed by Old Doctor Depression, is the only sure cure. The strangest thing about it is that it is the last thing industry thinks of taking when it is feeling bad, and then, when it begins to feel fine again, it downs the whole bottle and cries for more, like a teetotaler on a hair tonic spree.

Among the testimonials for this tonic, note first the fact that the replacement of obsolete, inefficient equipment need not—and when intelligently done never does—expand industrial capacity. This is an essential element of any effective industrial tonic, and the lack of any guarantee against it is a drawback in some of our favorite medicines for our current economic ills.

Beyond a certain limit which only a wizard could fix, every new investment in every old industry is an investment in depression, as the use of drugs or strong drink is an investment in the morning after. Modernization is homeopathic medicine indicated in mild industrial disorders. In acute illness large doses of something more drastic may be needed; but that is a story we have told elsewhere.

More important, perhaps, in this day of socially minded industry is the testimony of intelligent practitioners that modernization of equipment in established industries may be not a cause but a cure for unemployment. The continuous eczemous irritation of technological unemployment is a symptom of something other than mere efficiency; but this, too, is another story.

In the end, and at all times, profit is the sole stimulant of enterprise in our industrial system; and profitable enterprise is the sole protection of employment. Modernization is the mainstay of stable profits in every established industry and thereby the most important means of maintaining the fullest working force warranted by any sound economic standard.

Inefficient and unprofitable industry is no friend of labor, and no superimposed social legislation can assure stable employment where stable profits are impossible because of excessive capacity, much of which is represented by obsolete equipment. Modernization is a remarkable medicine precisely because it cures the doctors, nurses, internes and ambulance drivers as well as the patient, by increasing enterprise, investment, profits, employment and purchasing power simultaneously.

Get your bottle now!

LUBRICATING SYSTEMS

Self-Contained Types

Seventh article of a series. The next will appear in an early issue.

FRED H. LOW
Mechanical Engineer

BEYOND the point where central high-pressure systems are economical or practical, particularly for the cases where isolated bearings and other appliances require a continuous flow of lubricant, there are self-contained individual devices or systems made up of a reservoir and a feed mechanism that function in a manner similar to that of the fully automatic system.

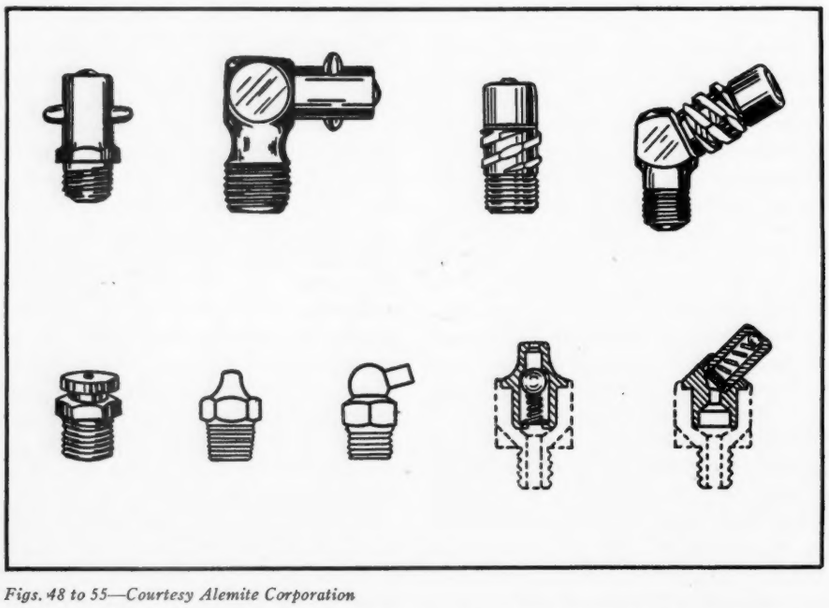
In this category are accumulators, similar to the one shown in Fig 47, which are made in various shapes and sizes to meet the different service requirements. These devices work on the principle of a plunger being forced into a cylinder by means of the pressure exerted by one or more springs. The type shown is a large-sized unit which is charged by means of a pressure gun.

Where there is considerable distance between bearings of the type that may be satisfactorily lubricated by grease or a semi-fluid lubricant, a system of individual fittings, to be serviced by means of a portable compressor, may be used economically to supply pressure lubrication. This system of lubrication is recommended by some manufacturers where conditions prevent the use of a fixed central system, and on equipment formerly considered best lubricated by machine oils.

In some cases these fittings are designed so that the pump or grease gun may be held in place simply by the pressure exerted by the operator. In other cases the fittings are provided with quick attaching and detaching devices which hold the gun tightly against the fitting. There are other cases in which a pipe-threaded fitting is used.

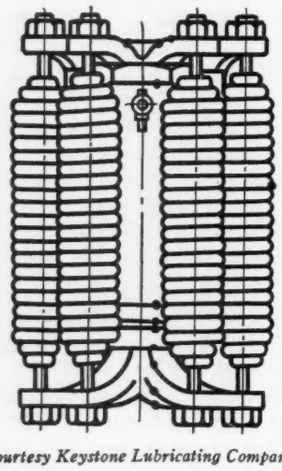
Although the former type of fitting lends itself to greater rapidity of application, the latter types obviously permit the use of high, sustained pressures, a feature which is desirable in some instances.

Several types of these fittings are shown in Fig. 48. The first two illustrated are pin type, which are coupled to the grease gun by a bayonet-type coupling. The third and fourth fittings have a part section of



Figs. 48 to 55—Courtesy Alemite Corporation

Fig. 48—Various types of fittings used with portable pressure grease guns. Some have pipe thread, others machine thread.



Courtesy Keystone Lubricating Company

Fig. 47—By means of spring-operated converters a continuous supply of lubricant (grease) may be provided. A pressure gun is used to charge this type with 4 lb. of grease.

the male Acme thread on them and the corresponding coupling on the grease gun has a female Acme thread. The fifth illustration is a button-head type, in which the coupling slides over the head. The last four fittings illustrated are of the contact type, in which the nozzle of the compressor forms a tight seal due to a spherical seat being formed in the compressor nozzle. The last two fittings belong in this group, but, by the use of adapters, can be driven directly into oil holes without the necessity of the hole being tapped. Where it is desirable to have a supply of lubricant in excess of the bearing capacity, the fittings may be furnished in connection with reservoir cups. A cup of this type is shown in Fig. 49 immediately below.

By referring to Fig. 48 it will be observed that these fittings are made in both drive and threaded types, and with the lead at various angles to facilitate the application of the lubricant in difficult places. Drive bushings of various diameters are used to simplify the installation of fittings in holes already drilled.

Of the many designs of applicators

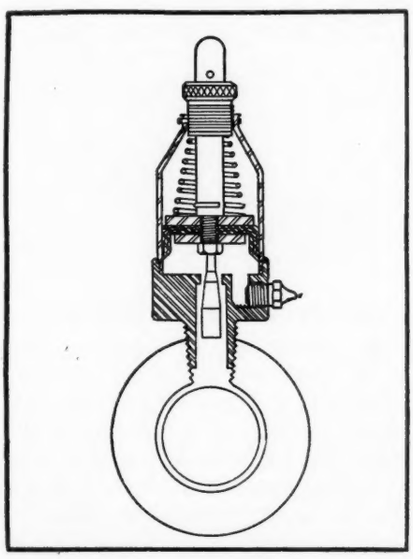


Fig. 49—Where a supply of grease is required at the bearing, cups with fittings for pressure lubrication are provided.

offered to meet the diversity of conditions, probably the simplest in construction and operation is the screw-plunger type shown in Fig. 50. This type of compressor may be equipped with either a T-handle, a wheel, or a crank. A check valve prevents the flow of grease from the compressor when it is detached from the fitting. The compressor may be made to contact with the fitting, or an extension of tubes and joints or flexible tubing may be used for this purpose.

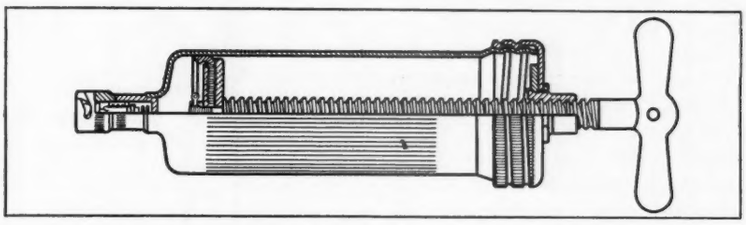


Fig. 50—A heavy-duty, check-valve compressor whose capacity is 14 oz. and which may be equipped with a T-handle, a wheel, or a crank.

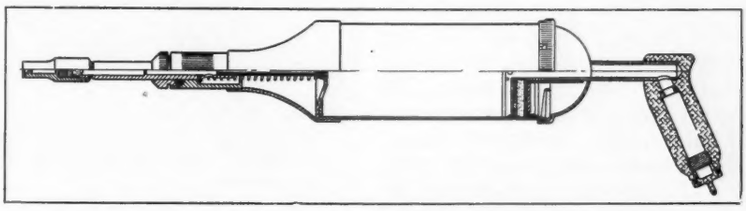


Fig. 51—Because of the small diameter of the pump, high pressures are obtained with little effort. The lubricant in the cylinder is carried toward the pump at each stroke.

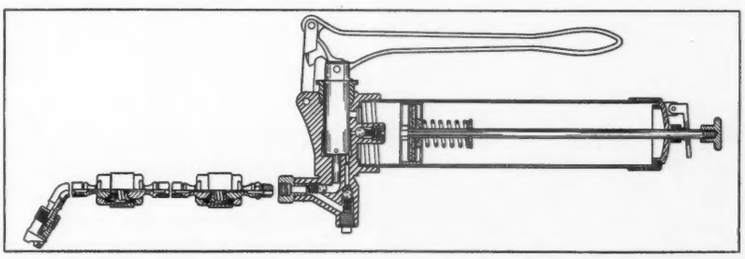


Fig. 52—Pressures up to 10,000 lb. sq. in. are developed in forcing semi-fluid lubricants into tight or frozen bearings with compressors of this type.

An automatic plunger-type gun is shown in Fig. 51, which operates as follows: Pressing the gun against the fitting causes the sleeves to slide back on the plunger, expelling the charge of lubricant into the bearing. When the pressure is released the spring returns the sleeve to its extended position. Automatically a ball-check closes the end port as a fresh charge of lubricant is being drawn into the sleeve. As the pressure is applied by means of the pistol-grip handle, the lubricant in the cylinder is forced toward the sleeve and nozzle at each application.

Where it is necessary to apply the lubricant under extremely high pressures, as is the case with heavy-bodied grease or with tight or frozen bearings, a compressor of the type shown in Fig. 52 is used. Raising the pressure plunger by means of the hand lever permits the lubricant to flow or to be forced into the pressure cylinder, from which it is forced into the bearing under a pressure of 10,000 lb. per sq. in. developed by the operation of the hand lever.

This type of gun may be used where it is desirable or necessary to use a flexible extension. By using compressors of the pressure-filled type it is possible to supply the lubricant from the barrel to the bearing without exposing it at any stage, thus eliminating the possibility of dirt or abrasives getting into the bearing through its application. Fig. 53 shows the pressure loader being filled from the barrel. The grease gun hanging on the side of the loader is filled through the pistol-grip handle by means of the pump on the top of the loader cylinder. Systems of this type give the

operator a large lubricant capacity and yet a light one-handed compressor for the lubrication of fittings.

In some instances high-pressure compressors of the type shown in Fig. 54 are equipped with a ratchet feed, so that each time the piston is operated the feed plunger is moved in maintaining a pressure on the supply of lubricant, thus insuring a full charge in the pressure cylinder at each stroke.

Where it is desirable to have a larger supply of lubricant in the applicator, devices similar to those shown in Fig. 54 are employed. In the units shown the pressure for application is built up by the pump which is attached to the tank. By means of a set of gears, in addition to a pawl and ratchet, the booster chamber is automatically primed at each stroke. Initial priming is effected by means of a hand crank. The lubricant

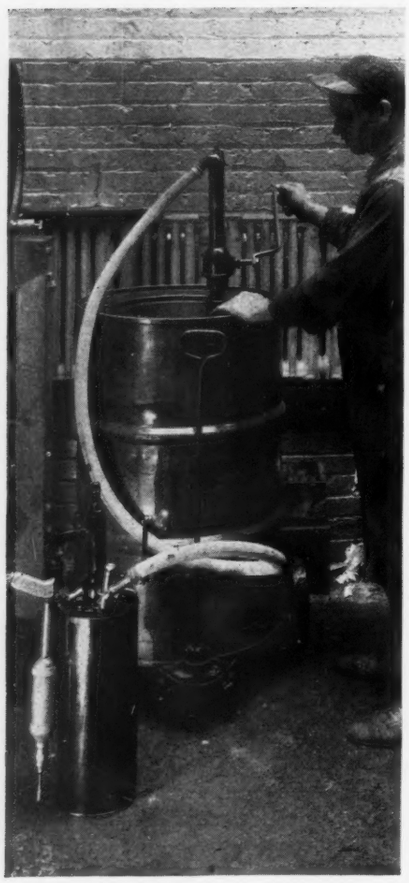
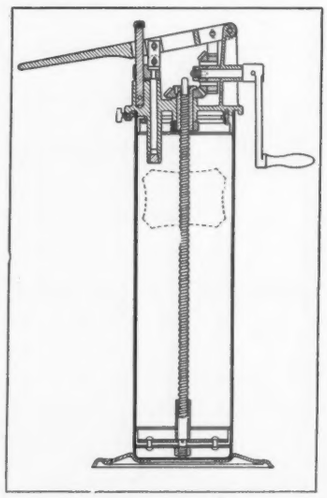


Fig. 53—By the use of pressure loaders the lubricant is never exposed to foreign matter.

is delivered to the bearing through a hose.

Smaller models of these units may be carried about by hand, whereas the larger models are made portable by



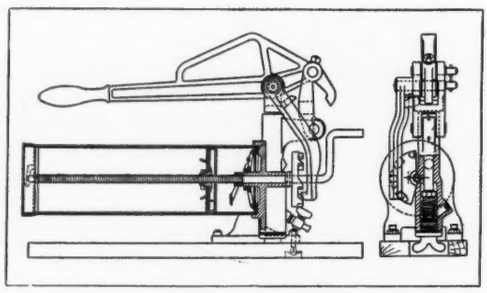


Fig. 54—Types of applicators used where large quantities of lubricant are required. These units may be mounted on casters.

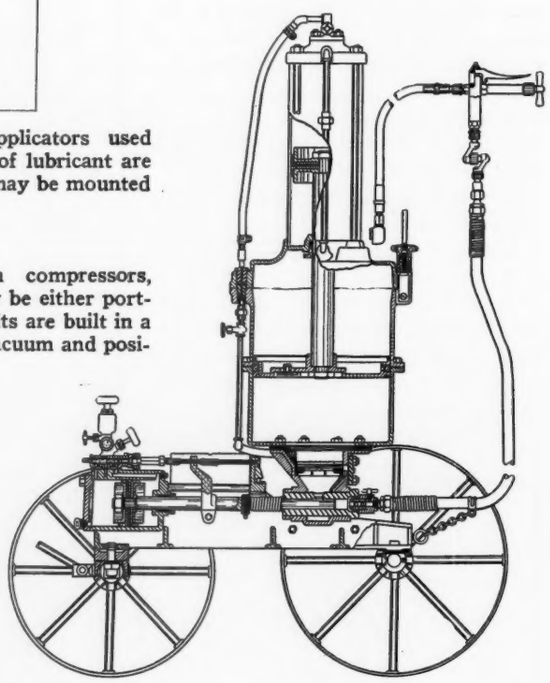


Fig. 55—Power-driven compressors, such as illustrated, may be either portable or stationary. Units are built in a variety of sizes, both vacuum and positively primed.

mounting on casters or on a hand truck.

Power-driven equipments, similar to that illustrated in Fig. 55, may be obtained to operate either with compressed air or electricity. They are built in a variety of sizes—both vacuum and positively primed—and can be either portable or stationary units. Where the portable unit is used, a flexible hose, release valve, and coupling are attached to the fitting and, the release valve depressed, the lubricant is allowed to flow through—the action of the release valve automatically controlling the flow of lubricant and the compressor. Where a permanent installation is made, the lubricant is piped to a number of outlets and the hose, release valve, and coupling are used the same way.

Where possible, leads are often installed from the bearings to a central or convenient point. With the system arranged in that manner there is less chance of the operator missing some obscure bearing, furthermore it is possible to operate some machines during the period that the lubricant is being applied. Ordinarily the equipment would be shut down because of danger to the oiler.

■ ■

Safety Code for Elevators

A NEW national safety code for elevators, dumb-waiters, and escalators, developed under the technical direction of the American Society of Mechanical Engineers, the American Institute of Architects, and the U. S. Bureau of Standards, has just been approved by the American Standards Association. Approval of the revised code by the Association followed nearly four years of research on elevator safety devices at the United States Bureau of Standards and extensive investigation by a technical committee composed of 38 representatives of architectural, engineering, governmental, and other organizations.

The code insists upon fireproof elevator shaft inclosures and fireproof housing for the elevator machinery so that elevator evacuation of a fire-swept building will be possible.

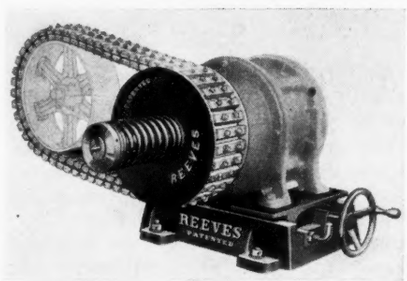
EQUIPMENT NEWS

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these devices, which are designed to improve plant operation or reduce operating and maintenance costs.

Reeves "Vari-Speed" Motor Pulley

REEVES Pulley Company, Columbus, Ind., announces the development of a simplified type of variable-speed transmission known as the "Vari-Speed" motor pulley. It is mounted directly on the motor shaft and forms the driving element between the motor and the driven shaft. By turning a handwheel, infinite speed control is obtained between a ratio limitation of 3 to 1. Six sizes are available, applicable to a.c. or d.c. motors up to 7½ horsepower.

The unit consists of an assembly of two opposing cone-faced disks, one stationary and one sliding, and an adjustable power compression spring, all of which are self-contained and mounted on the motor shaft; a special motor base and a handwheel; and a V-belt that



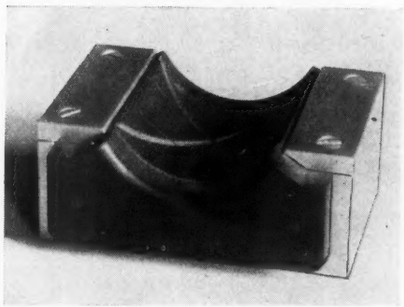
contacts on its sides between the cone-faced disks and on its flat surface with the face of the driven pulley. Wood, metal, or composition straight-face pulleys may be used on the driven shaft.

By turning the handwheel in one direction, the motor is moved away from the driven pulley. This action causes the V-belt to assume a smaller diameter between the cone-faced disks, the sliding disk moving laterally but held in contact with the V-belt by means of the compression spring. Thus the speed of the driven pulley is reduced. When the handwheel is turned in the opposite direction, the reverse is true.

■

Westinghouse Micarta Roll-Neck Bearings

ROLL-NECK bearings lined with Micarta, a phenolic resinous material, have been announced by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. In applications such as are found in wire, rod, bar, and merchant mills in which the pressure is not excessive and the peripheral speeds range from 100 to 1,000 f.p.m., the bearings have given economical service. The units use water as a lubricant. The Micarta lining resists the action of weak acids and alkalis as well as sand, grit, and scale in the lubricating water.



The three essential parts which comprise the bearing are the radial segments, thrust block, and housing. The radial segments usually are 120-deg. pieces so constructed that the wear at any point is at right angles to the grain of the material. The thrust block consists of a separate piece of Micarta so mounted that the edge of the roll rubs against the grain. The thrust block and radial segments are assembled in a machined housing and are held tightly in place. The thrust collar is prevented from turning by a recess machined in the metal housing. Either the thrust collar or radial segments may be replaced independently. Distribution channels are machined in the bearing surface to facilitate cooling and lubrication.

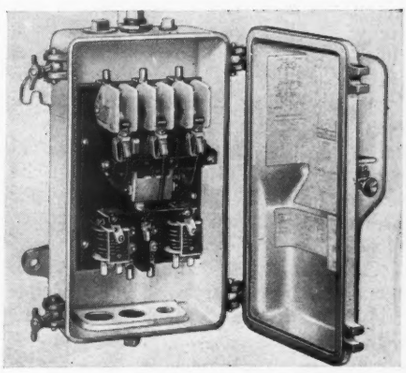
■

Worthington Pump Acquires Metalweld

ACQUISITION of the manufacturing and marketing facilities of Metalweld, Inc., Philadelphia, Pa., manufacturers of portable compressor units, has been announced by the Worthington Pump and Machinery Corporation, Harrison, N. J. The portable compressors will be manufactured at Worthington's Harrison, N. J., Works. The personnel of the Metalweld organization also will be moved to this plant.

Allen-Bradley Splash-Proof Starters

ALLEN-BRADLEY Company, 1311 South First St., Milwaukee, Wis., announces a line of splash-proof, across-the-line starting switches known as Bulletin 710 WT., for squirrel-cage motors. They are designed for use in laundries, packing plants, creameries, rayon plants, and other places in which the splash-proof feature is desirable. Starters are rated for motors up to 100 hp., 220 volts, and 200 hp., 440-550 volts. They also may be used on slip-ring motors to control the primary cir-



cuit up to the maximum ratings listed for squirrel-cage motors. If thermal relay reset buttons are omitted from the side of the cabinets, starters are said to be watertight.

■

Wheeler Reflector Company Opens Subsidiary Plant

WHEELER Reflector Company, Boston, Mass., announces the opening of a subsidiary plant at 44 York St., Toronto, Canada. This plant, known as the Wheeler Reflector Company of Canada, Ltd., will manufacture the complete line of lighting fixtures.

■

Tagliabue Steam Trap

C. J. TAGLIABUE Manufacturing Company, Park and Nostrand Aves., Brooklyn, N. Y., announces a steam trap with a differential setting

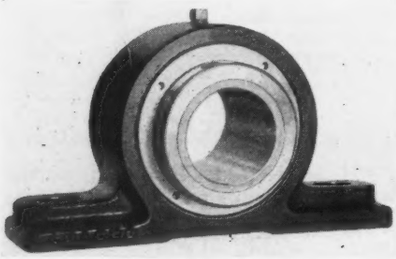
feature. This device makes it possible for the trap to discharge condensate at a temperature corresponding to a uniform differential pressure from 0 to 20 lb. per sq. in. below the operating steam pressure. Adjustment of a differential setting screw fixes the discharge at a given value in the range. When the screw is all the way up on the trap, there is no tension on the spring and the trap will discharge condensate from 1 to 2 deg. below the temperature of the operating steam. When the setting screw is turned down, a mechanical pressure is created on the inside of the bronze bellows which aids the vapor pressure developed in the bellows to close the valve.

Other features include a reversible monel-metal seat and disk and a bronze body. Traps are available only in the 1-in. size with a $\frac{5}{16}$-in. valve opening.

■

Shafer Self-Aligning Roller Bearings

NORMAL-DUTY, self-aligning roller bearings have been announced by the Shafer Bearing Corporation, 6501 West Grand Ave., Chicago, Ill. Bearings may be furnished as pillow blocks, flange units, or take-up units for shaft sizes ranging in diameter from $\frac{3}{4}$ to 3 in. General construction is the same as the heavier, standard-duty units, retaining the concave-roller, convex-raceway assembly which compensates automatically for minor inaccuracies in machining and mounting or deflection of the shaft under load. Inner races are extended on one side only and are fastened to the shaft by a locking collar. The bearings are sealed by two steel stampings pressed into the housing, between which is a 3/32-in. fiber washer.



■

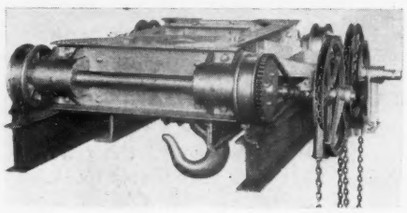
Carolina Wood Preserving Company Purchases Prettyman Wood-Preserving Plant

J. F. PRETTYMAN & Sons, Summerville, S. C., announces that its wood-preserving plant has been purchased by the Carolina Wood Preserving Company, Charleston, South Carolina.

■

Robbins & Myers Hand-Power Crane

THE HOIST & Crane Division of Robbins & Myers, Inc., Springfield, Ohio, announces a low-headroom, hand-operated crane which, although designed specifically for use in pipe-line compressor stations and power houses, is adaptable to other industrial applications. The crane will give a higher lift for the same ceiling height than standard types of hand-power cranes because

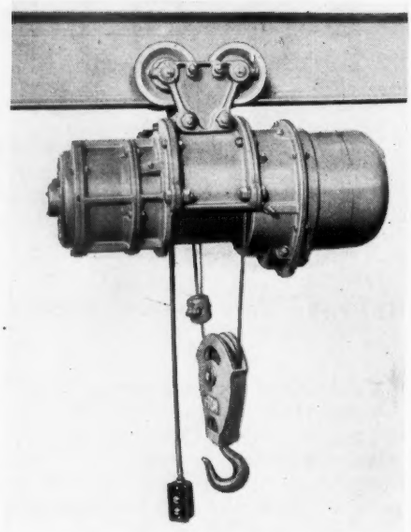


of its special design. It is equipped with roller bearings throughout. Other features are welded-steel construction, alloy-steel gears, "Aremite" trolley wheels and chain sheaves, a two-speed hand-wheel, roller-chain drive, and a twin-disk load brake.

■

Wright Electric Trolley Hoists

WRIGHT Manufacturing Company, Bridgeport, Conn., announces that its line of hoists now is available in the plain, geared, and motor-driven trolley types. Trolley-wheel bearings are designed to absorb both radial and thrust loads. In the motor-driven types the wheels are driven on each side of the I-beam. Controllers can be furnished for single-speed, two-speed, or variable-speed operation. Hoists can be mounted either

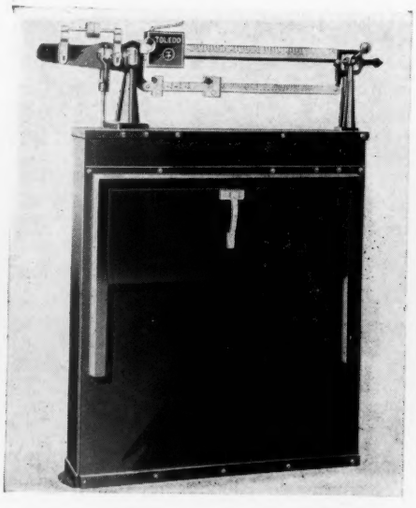


parallel or at right angles to the runway beam. While the standard lift is 18 ft., lifts of 9 and 36 ft. can be furnished. A description of the line together with an illustration of a hoist equipped with hook-type suspension was published in the March, 1931, issue of *Industrial Engineering*.

■

Toledo "Convert-O-Matic" Scale

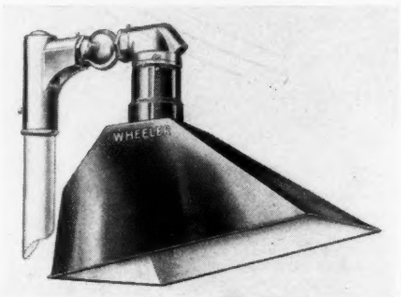
ANNOUNCEMENT is made by The Toledo Scale Company, Toledo, Ohio, of a beam scale, known as the "Convert-O-Matic," which may be transformed quickly into an automatic, indicating scale by the addition of an indicating dial. Another important feature of the unit is that its total weighing capacity may be increased one to four times by adding unit weights in the cabinet of the scale as desired. A full-floating platform, pressed-steel cabinet, and interchangeable pivots which may be changed without honing or grinding are other characteristics of the scale.



Wheeler "Jumbo-Isolux" Floodlight

WHEELER Reflector Company, 275 Congress St., Boston, Mass., announces a wide-angle floodlight for general outdoor use which bears the trade name "Jumbo-Isolux." Its flat reflecting planes, rectangular light outlet, and straight-line cut-off are designed to provide a broad, even flood of light without highlights or shadows.

The floodlight is a two-piece unit, consisting of a porcelain-enameled steel

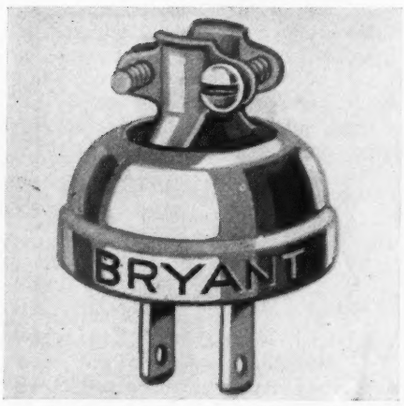


reflector and a cast-aluminum canopy. The canopy is equipped with a porcelain socket which accommodates a 750-, 1,000-, or 1,500-watt general-service lamp. If desired, a chromium-plated interior reflector may be provided for greater intensity and longer light beams. Adjustable brackets are available for mounting the reflector so that it may be adjusted to any angle in both vertical and horizontal planes.

■

Bryant Electric Attachments

TWO attachments, known as the "Spartan" No. IX armored cord-grip cap and the "Spartan" No. 5103 armored cord connector, have been announced by The Bryant Electric Company, Bridgeport, Conn. The body of No. IX is of composition, steel-armored and cadmium-plated, with a $\frac{7}{16}$-in. cord hole. No. 5103 is a companion cord connector with a body of brown composition, steel-armored and cadmium-plated, and a $\frac{7}{16}$-in. cord hole.

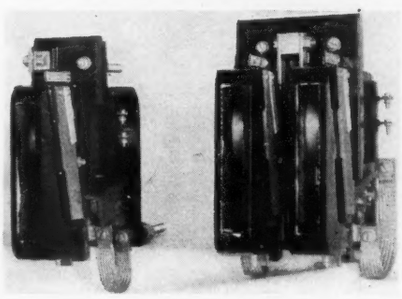


The two devices are adapted especially to industrial plants, garages, and other places where cords are subjected to rough handling.

■

Westinghouse Heavy-Duty Contactors

HEAVY-DUTY contactors for steel-mill, crane, and general-purpose d.c. magnetic controllers have been announced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. Contactors may be mounted closely together because all parts may be removed from the front for repair or replacement. Effective rupturing capacity is obtained by high-



speed operation and the design of the arc box and horns along which the high-flux blowout forces the arc.

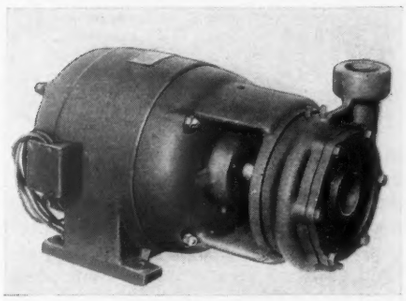
■

Cleveland Tramrail

LOADS up to five tons may be handled by the 5100-Type Tramrail announced by the Cleveland Electric Tramrail Division of The Cleveland Crane & Engineering Company, Wickliffe, Ohio. Design is such that 10-ton loads may be carried by a suitable arrangement of carriers, cranes, and trucks. The equipment retains all the features of the lighter 2-ton type such as an arch-beam rail; the usual long-wheelbase carriers with swivel yokes and double-row ball-bearing wheels; and underslung-type cranes with swivel-end trucks.

Worthington "Monobloc" Centrifugal Pumps

TYPE D "Monobloc" centrifugal pumps have been announced by the Worthington Pump and Machinery Corporation, Harrison, N. J. Each unit is constructed so that the pump is bolted to the extended motor frame, the impeller being mounted on the end of the continuous motor shaft. The bronze impeller incorporates the shaft sleeve as an integral part. A cadmium-plated-steel locking device for the impeller,

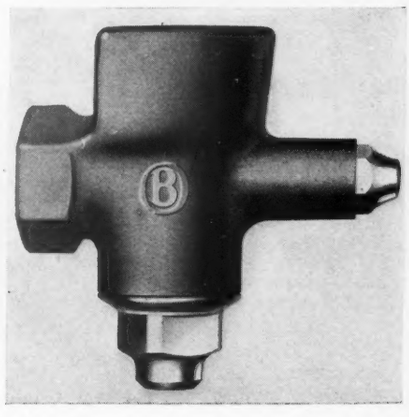


a forged-bronze packing gland, and an unusual arrangement of shaft water-throwers are other features of the pump. The ball-bearing motor is designed especially for the unit and incorporates standard electrical construction. Among the applications of the unit are its use as a built-in part of assembled equipment in air-conditioning apparatus, washing machinery and filter systems.

■

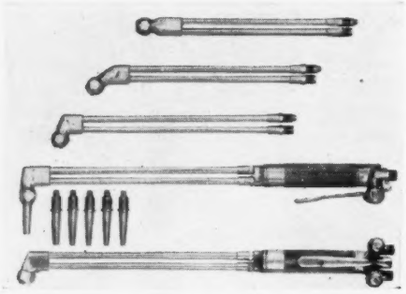
Ohio Brass Blow-Gun Valve

OHIO Brass Company, Mansfield, Ohio, announces that it has added a blow-gun valve to its line. The valve thumb button is surrounded by a flange of metal to protect it from rough use and to eliminate the possibility of accidental opening of the valve. The disk is made of a soft composition and fits into a machined seat, where it is held in positive contact by a spring as well as by the pressure of the air itself. The valve stem cannot slip out when the cap is removed to renew the disk.



Bastian-Blessing "Rego" Cutting Torch

TYPE CC "Rego" cutting torch is announced by The Bastian-Blessing Company, 240 East Ontario St., Chicago, Ill. The unit weighs 46 oz. and

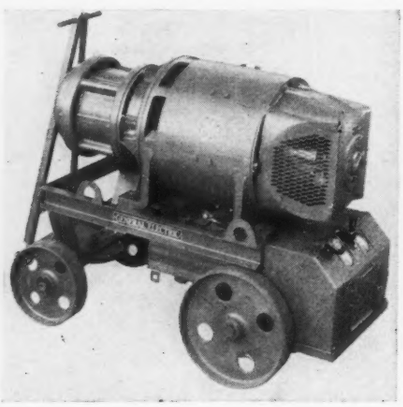


has an overall length of 20¼ in. with the tip in place. By using a suitable tip, the unit can be made adaptable for use with acetylene, hydrogen, carbo-hydrogen, oxy-acetylene, and liquefied-petroleum gases. Tips are made of one-piece copper or a brass core with copper protection. Pre-heat holes are grouped closely to concentrate the flame. The torch head may be furnished straight or with a 35-, 75-, or 90-deg. angle bend.

■

General Electric Welding Sets

SINGLE-OPERATOR welding sets have been announced by the General Electric Company, Schenectady, N. Y. The line, known as WD-20, consists of five types—100-, 200-, 300-, 400-, and 600-amp. machines. Although the basic form of the sets is stationary, a slight change will make them portable. Types include those for operation on either alternating current or direct current at all standard voltages and, in the case of alternating current, frequencies. Two- and three-phase gasoline-engine-driven sets also are available. Two-bearing construction is provided on the a.c. types up to 600 amp. Sets are self-excited and are provided with a tapped series field for major current adjustments and a shunt-field rheostat for duplex voltage control. They are designed to give practically instantaneous voltage recovery from short circuit to nearly full open-circuit voltage, thus giving a quickly responsive arc. A 300-amp., portable set is shown.



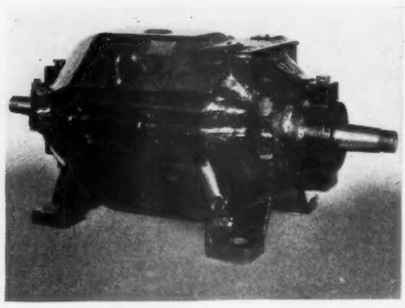
■

Westinghouse Steel-Mill Motor

WESTINGHOUSE Electric & Manufacturing Company, East Pittsburgh, Pa., announces a steel-mill motor designed for heavy-duty applications, such as steel-mill auxiliary drives, cranes, hoists, coal and ore bridges, mine hoists, and so on. In its design this motor embodies the latest recommendations of the Association of Iron and Steel Electrical Engineers.

Bearing housings accommodate, interchangeably, any standard ball or roller bearings, with oil or grease lubrication. Laminated commutating poles are employed to prevent injurious sparking and give improved performance, particularly on plugging and reversing.

The motors have heavy cast-steel frames, split horizontally, permitting

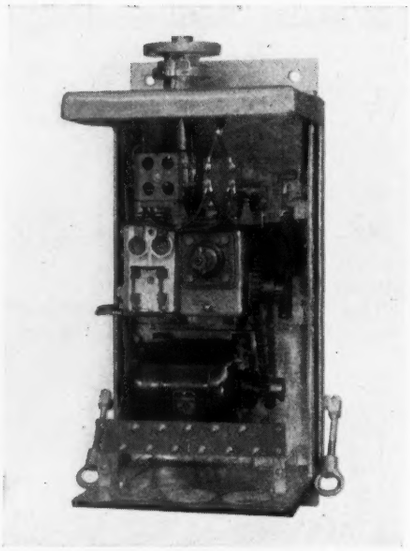


the top half to be swung back without disconnecting any leads. The halves are hinged on self-supporting hinges.

■

Delta-Star Switch-Operating Mechanism

DELTA-STAR Electric Company, 2400 Block, Fulton St., Chicago, Ill., has developed a self-contained motor-operated mechanism for use with gang-operated disconnecting switches. A toothed coupling on the main shaft at the top of the unit attaches to the switch-operating shaft. At the front is a shaft extension for hand operation in case of an emergency. In the welded-steel housing is mounted the motor with its chain drive to the speed-reducing gears. Auxiliary switches, clutch-control mechanism, the service switch with its fuses, and terminal boards are mounted as shown.

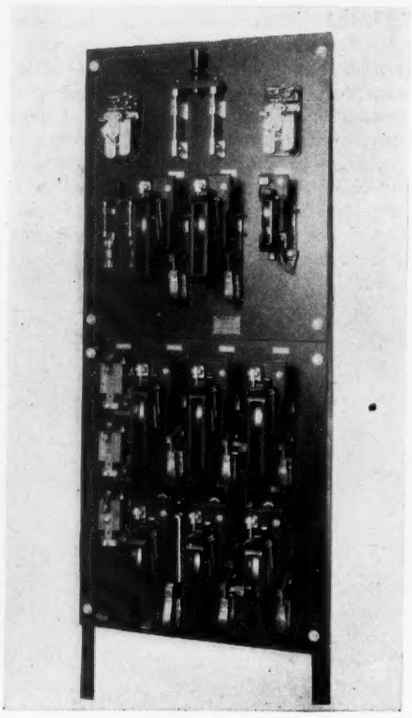


When the housing cover is removed, all control parts are visible for inspection or repair. The cover fits on a gasketed groove.

■

Westinghouse D. C. Controllers

MAGNETIC controllers, designed for heavy-duty service with series-, shunt-, or compound-wound d.c. motors, have been developed by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. They are designed for such mill and materials-handling applications as roll tables, screwdowns, shears, bar pullers,



ingot buggies, cranes, ore bridges, car dumpers, and other types of service requiring quick and accurate stopping.

The control panel consists of an asbestos-lumber base supported on an angle-iron frame. Type SM contactors of high rupturing capacity are employed on the panels. Inverse time-limit overload protection is provided by a thermal overload relay, which trips instantaneously on abnormal overloads. The relays reset instantaneously.

■

Hollands "Quick-Action" Chain Pipe Vise

RAPID and positive cam adjustment features the chain pipe vise announced by the Hollands Manufacturing Company, Erie, Pa. The adjustment nut is used only when working on different sizes of pipe. Adjustment of the lever gives rapid tightening or release. The vise weighs 15 lb. and has a capacity ranging from ⅛- to 4-in. pipe.

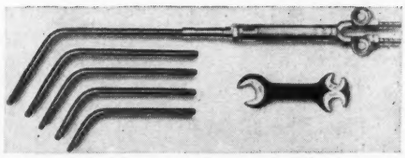
■

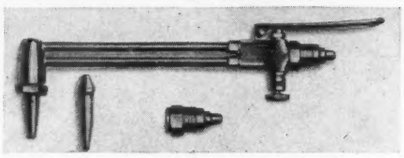
Linde "Purox" Welding Torch and Cutting Attachment

TWO ADDITIONS to its line of "Purox" medium-pressure apparatus for oxy-acetylene welding and cutting have been announced by The Linde Air Products Company, 30 East 42nd St., New York, N. Y. They are the No. 11 welding torch and the No. 21 cutting attachment.

The welding torch, which supersedes the No. 10 torch, has a welding range extending from the lightest sheet metal up to ½-in. plate. Tips are constructed of one-piece, hard-drawn copper and are designed so that the head angle can be adjusted as desired by the user. Tips Nos. 2, 4, 6, 8 and 10 are furnished as standard equipment.

The cutting attachment is designed for use with the welding torch and will cut metal up to 2 in. in thickness. It is



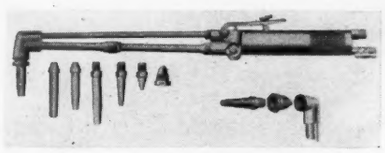


furnished with one- and two-piece cutting tips. By means of the attachment the welding torch can be converted into a cutting torch. The attachment is 1½ lb. in weight. An adaptor also is available which makes it possible to use the No. 21 cutting attachment with the No. 20 welding torch.

■

Milburn Cutting and Welding Torch

TYPE RIF-A cutting and welding torch has been announced by The Alexander Milburn Company, 1416 West Baltimore St., Baltimore, Md. Principal parts are of forged bronze with tubes of nickel silver. The seats

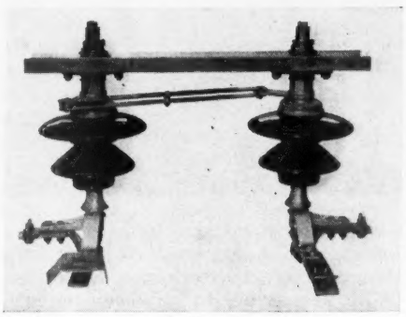


of the high-pressure valve may be renewed without disassembling the handle or other parts. The head is designed to take conical-seated tips Nos. 1RIF to 8RIF. The torch may be converted from a cutting torch into a welding torch by use of an adaptor, which is designed to use Type FX or similar welding tips.

■

Delta-Star Gang-Operated Switch

DELTA-STAR Electric Company, 2400 Block, Fulton St., Chicago, Ill., has developed a high-voltage,

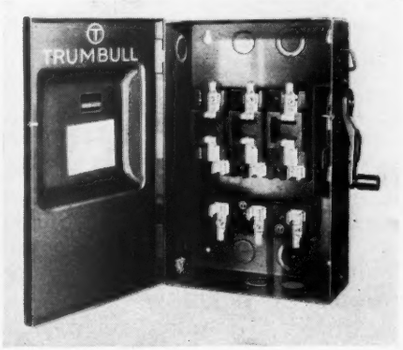


gang-operated, three-pole disconnecting switch, said to require no more insulators and take up no more space than three single-pole, hook-operated disconnects. Both insulators for each pole rotate, giving a horizontal center break with short blades, so that phase-to-phase spacing can be less than that required for switches with one rotating insulator per pole. The single-pole element illustrated shows two insulators interlocked for gang operation. Units are made for a 7.5- to 161-kv. range of service.

■

Trumbull "R.B." Safety Switches

"R. B." IS the trade name of a line of heavy-duty safety switches announced by The Trumbull Electric Manufacturing Company, Plainville, Conn. Receding-blade construction and double-break contacts are features.



■

Lincoln "Hardweld" Electrodes

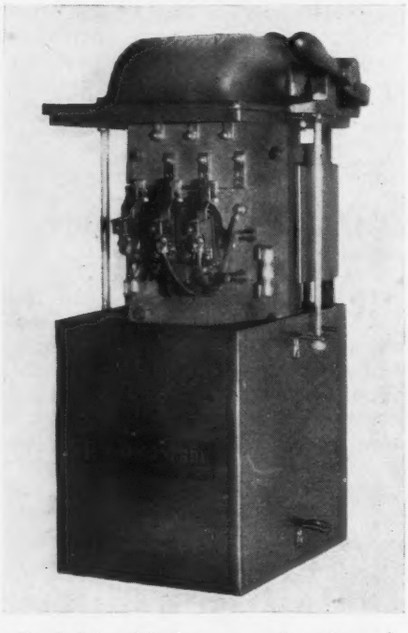
ELECTRODES, containing 1.00 per cent carbon, to be known as "Hardweld," have been announced by The Lincoln Electric Company, Cleveland, Ohio. They are designed for use in building up cupped or worn rails, locomotive tire flanges, car wheels, oil-well drill bits, tractor shoes, dipper teeth, dies, and other wearing surfaces. It is claimed that the weld produced has a tough dense surface of moderate hardness that will resist wear and abrasion. When used on straight high-carbon steel and allowed to cool naturally, the deposit is said to have a hardness within the following range:

Rockwell C	Schoroscope	Brinell
30 to 45	40 to 61	290 to 425

The electrodes are to be used on reversed polarity with low-arc voltages of 20 to 25 volts. They are made in $\frac{3}{32}$-, $\frac{5}{16}$-, and ¼-in. diameters in 14-in. lengths, and are packed in tin containers in 25-lb. lots.

Rowan Safety Switch

ROWAN CONTROLLER Company, Baltimore, Md., has introduced a combination safety switch and magnetic contactor for use with small a.c. motors. Working parts are immersed completely in oil. The protection against vapor, weather, and dust

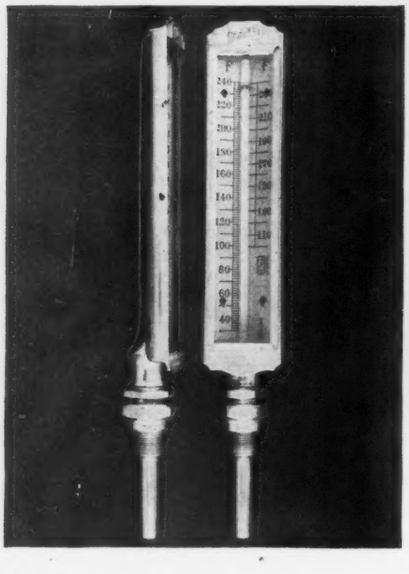


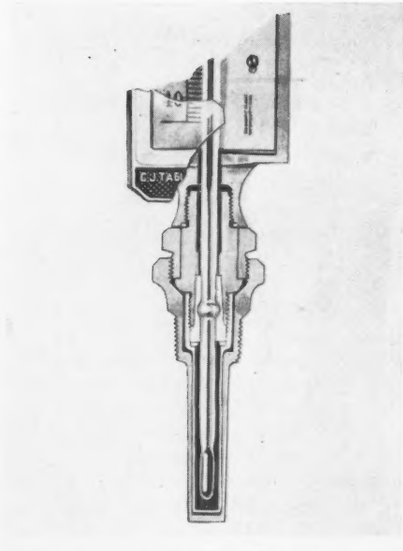
afforded by this feature makes the unit especially adaptable for application in steel mills, gypsum plants, oil refineries, and cement plants. The equipment can be furnished in sizes up to 5 hp. for 220-, 440-, or 550-volt circuits.

■

Tagliabue Industrial Thermometer

AN INDUSTRIAL thermometer featuring a snap case-front has been announced by the C. J. Tagliabue Manufacturing Company, Park and Nos-



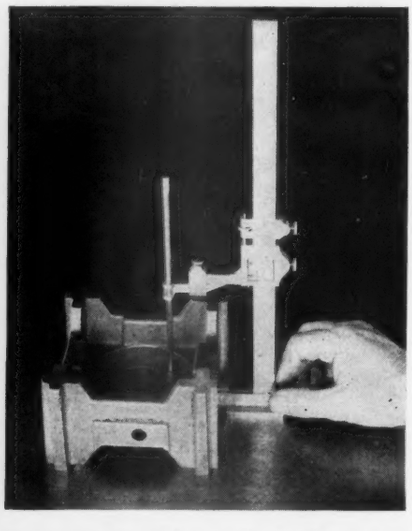


trand Aves., Brooklyn, N. Y. The case-front may be removed for cleaning and, when returned in position on the instrument, it is held in position by a snap device. A tongue at the top of the case fits into a groove in the front to facilitate its removal or replacement. Other features are: connecting piece locked to the case by a split spring washer; asbestos packing compressed around enlargement on glass stem to prevent movement in tube with reference to scale; and monel-metal bulb chamber.

■

Brown & Sharpe Depth-Gage Attachments

TWO DEPTH-GAGE attachments for converting height gages to depth gages have been announced by the Brown & Sharpe Manufacturing



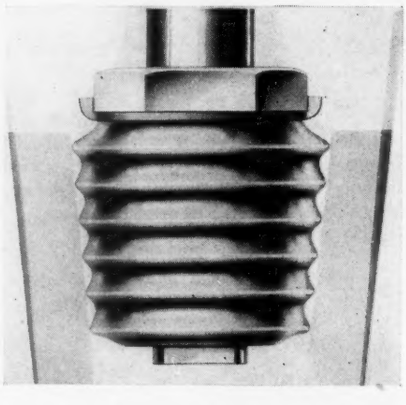
Company, Providence, R. I. They are known as Nos. 585A and 585B and are designed for use with the 10-in. and 18-in. Vernier height gages respectively. Attachments are locked into place on the height gage by means of a clamp screw. Measurements may be taken over high projections or in deep recesses.

■

Ludlow Multi-Valve

THE LUDLOW Valve Manufacturing Company, Troy, N. Y., announces a multi-stage valve, the principal feature of which is a multi-stage cone or plug.

The cone is corrugated with specially curved grooves in its side, forming a



number of contact rings that seat against the converging wall of the outlet. The grooves form annular expansion chambers, the area of each chamber increasing with the increase in the circumference of the cone, thus reducing the density and velocity of the fluid step by step and forming separate back-pressure pockets which retard the flow of the medium. The stainless-steel cone swivels on its stainless-steel stem. As long as the beaded lands are in contact with the converging walls of the seat, the cone cannot revolve but, once free from the seat, it rotates with the spindle. In this way the cone corrects any tendency to leak by presenting a new sealing surface for contact with each successive seating. As the valve is opened and closed, the action of the beaded lands on the plug walls tends to remove any possible scale and burnish the lands and walls.

The valve may be used for steam, air, gas, water, oil, or viscous liquids and solutions. The illustration shows the multi-stage cone only.

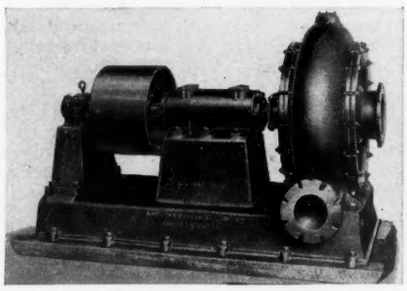
■

Diamond Asbestos Sheet Packing

ASBESTOS sheet packing designed especially for use with hot oil has been announced by The Diamond Rubber Company, Inc., Akron, Ohio. Under the standard compression test, a pressure of 40,000 to 45,000 lb. per sq. in. is required to cause it to fail.

American Manganese Steel Type C Pump

AMERICAN Manganese Steel Company, Chicago Heights, Ill., announces the addition of a manganese-steel pump, known as Type C, to its

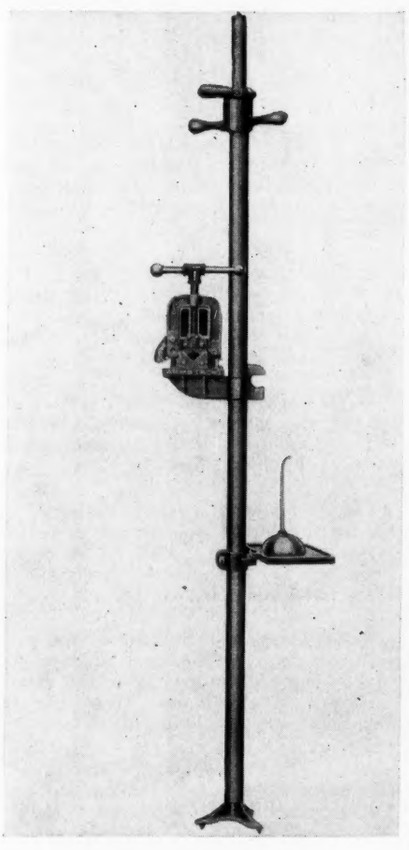


line of pumps for handling abrasive materials. Added features include interchangeable bearings of either sleeve or anti-friction type, adjustable main bearings, and adjustable impeller clearance. Except where outboard bearings are used, only the main bearings require lubrication.

■

Armstrong Vise Posts

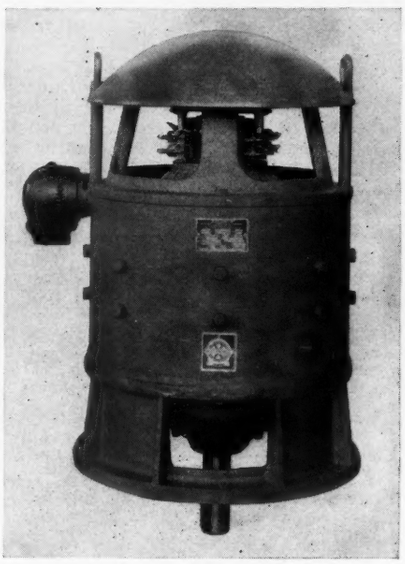
PORTABLE vise posts have been announced by The Armstrong Manufacturing Company, Bridgeport, Conn. An important feature is the "Feather Touch" lock shown at the top of the post in the illustration. The lock consists of a cam which stops downward motion except when its handle is raised to adjust the post and a pair of grips which are turned only when tightening the post. Other features are a tri-foot, self-balancing base and a detachable oiler and tool tray.



■

Reliance Vertical D.C. Motors

VERTICAL d.c. motors, known as Type T, have been announced by The Reliance Electric & Engineering Company, 1042 Ivanhoe Rd., Cleveland, Ohio. They are provided with a ring base for mounting and a drip cover to protect them from falling dirt and chips or from dripping water and oil. When desirable, motors without ring bases can be mounted directly to the machines



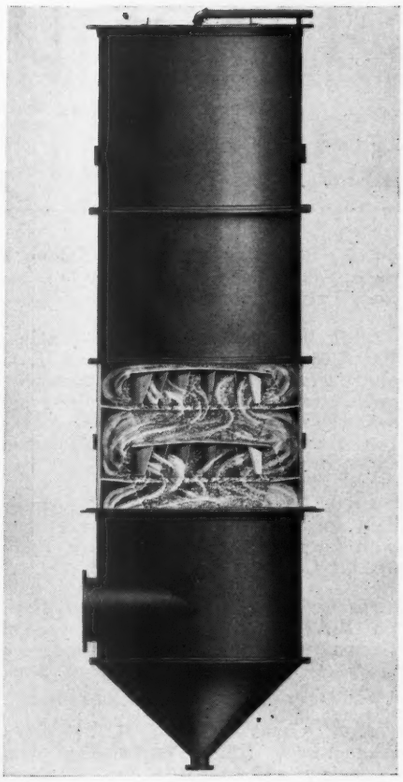
being driven, appearing as integral parts. Eye-bolts facilitate handling. General construction is the same as Type T d.c. heavy-duty motors for horizontal operation.

■

Schneible "Multi-wash" Dust Collector

CLAUDE Schneible, 35 East Wacker Drive, Chicago, Ill., announces the development of a wet-type dust collector known as the "Multi-wash."

Dust-laden air, vapor, gas, or other material to be cleaned or recovered is introduced at the bottom of the tower in a direction tangent to the periphery. The water or other cleaning liquid enters at the top of the tower and falls through a number of plates in the form of spray. The arrangement of plates and vanes inside the collector is designed so that the air or vapor continues to spiral on its upward course, thus



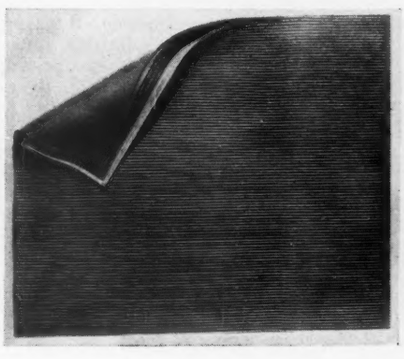
meeting the falling liquid. Six plates are incorporated in the standard collector which, with two washes per plate, provides a total of twelve washes. The clean air escapes from the top of the tower, whence it may be recovered or exhausted.

The unit may be built of practically any desired material and in different sizes to suit conditions.

■

Diamond Rubber Matting

RUBBER matting for use as a safety insulator for the operators of power switchboards has been announced by The Diamond Rubber Company, Inc., Akron, Ohio. It is ¼ in. thick and is guaranteed to withstand 15,000 volts under the voltage test, and 40,000 volts under the dielectric test as specified by the American Society for Testing Materials.



TRADE LITERATURE

For copies, address the manufacturers concerned

■

(298) ELECTRICAL CONTROL — Folder, 8 pages, Square D Switch.—Square D Company, Detroit, Mich.

(299) TEMPERATURE CONTROL — Catalog 1000, 103 pages, complete line of TAG controllers, recorders, dials, thermometers, hydrometers, oil-testing instruments, and moisture meters.—C. J. Tagliabue Manufacturing Company, Park and Nostrand Aves., Brooklyn, N. Y.

(300) BEARINGS—Bulletin 102, 8 pages, data for spindle and bearing mounting, with latest price sheets.—Wyrick Engineering Company, Wyandotte, Mich.

(301) SWITCHGEAR ACCESSORIES—Bulletin GEA-938B, 23 pages, various types of clamps, terminals, brackets, cleats, and plugs.—General Electric Company, Schenectady, N. Y.

(302) GEARS — Catalog 31, 100 pages, photographs, tables, engineering data, formulas, and complete list of gears manufactured.—The Earle Gear and Manufacturing Company, 4707 Stanton Ave., Philadelphia, Pa.

(303) ELECTRICAL CONTROL — Folder, 4 pages, the No. 2 Type ZO motor starter. —The Electric Controller and Manufacturing Company, Cleveland, Ohio.

(304) COAL HANDLING—Bulletin 906 describes and illustrates the Type C Pulverizer.—Fuller Lehigh Company, 85 Liberty Street, New York, N. Y.

(305) PLASTIC PRODUCTS — Bulletins GEA-1429, GEA-1456, GEA-1457 and GEA-1458; the first, 24 pages, illustrates and describes "Textolite," "Fabroil," and "Cetec," patented plastic compounds; the second, 4 pages, is devoted exclusively to "Cetec"; the third and fourth, both 4-page folders, describe and illustrate "Textolite."—The General Electric Company, Schenectady, N. Y.

(306) WIRE ROPE AND WIRE—General catalog, 279 pages, gives complete illustrated list of the products offered, together with engineering data and wire tables.—John A. Roebling's Sons Company, Trenton, N. J.

(307) STEEL BARS—Bulletin, 8 pages, describes a variety of steel shafting, screw stock, and open-hearth case carburizing steels; well illustrated.—Joseph T. Ryerson & Son, Inc., Chicago, Ill.

(308) GASKETS—Catalog H, 100 pages, a reference manual for data on gaskets, gasket materials, and packings for industrial and commercial uses.—Victor Manufacturing & Gasket Company, 5750 Roosevelt Rd., Chicago, Ill.

(309) SWITCHGEAR — Bulletin GEA-1184A, describes and illustrates the CR7006-D30B magnetic switch for across-the-line induction-motor starters.—General Electric Company, Schenectady, N. Y.

(310) POWER TRANSMISSION — Pamphlet, 8 pages, illustrates and describes the Davis flexible coupling, giving available sizes and dimensions. — Penn Machine Company, Station St., Johnstown, Pa.

(311) PIPE LINES—Armco Engineering Bulletin, Vol. 1, No. 3, 4 pages, gives data for designing high-pressure pipe lines.—The American Rolling Mill Company, Middletown, Ohio.

(312) GEARS—Bulletin, single leaf, describes gear blanks made of arc-welded rolled steel.—Lukenweld, Inc., Coatesville, Pa.

(313) ELECTRICAL CONTROL — Bulletin CA-505-A, supplementary section to Bulletin CA-505, shallow-type convertible safety panelboard, with capacities up to 100 amp. and 250 volts.—Square D Company, Detroit, Mich.

COMING EVENTS

American Welding Society—Fall Meeting and Exposition, Boston, Mass., Sept. 21 to 25, Secretary, A. V. Hutchinson, 51 Madison Ave., New York, N. Y.

National Metal Congress and Exposition—Exposition, Commonwealth Pier, and Congress sessions, Hotel Statler, Boston, Mass, Sept. 21 to 26. W. H. Eisenman, Secretary, A.S.S.T., 7016 Euclid Ave., Cleveland, Ohio.

National Safety Council—20th Annual Safety Congress, Chicago, Ill., Oct. 12 to 16. Headquarters, Civic Opera Building, Chicago, Ill.

Illuminating Engineering Society—Annual Convention. Hotel William Penn, Pittsburgh, Pa., Oct. 13 to 16. Assistant Secretary, Frank G. Horton, 29 West 39th St., New York, N. Y.

American Gear Manufacturers Association—Semi-annual meeting, William Penn Hotel, Pittsburgh, Pa., October 15 to 17 inclusive. Secretary, T. W. Owen, 3608 Euclid Ave., Cleveland, Ohio.

American Society of Mechanical Engineers—Annual meeting, New York City, Nov. 30 to Dec. 4. Secretary, Calvin W. Rice, 33 West 39th St., New York, N. Y.

First National Exposition of Mechanical Handling Equipment—Grand Central Palace, New York, N. Y., Nov. 30 to Dec. 5. Charles F. Roth, secretary.

Second International Heating and Ventilating Exposition—In conjunction with the American Society of Heating and Ventilating Engineers and the American Society of Refrigerating Engineers, Cleveland, Ohio, January 25 to 29, 1932. The Exposition is under the direction of the International Exposition Company, Grand Central Palace, 46th St. and Lexington Ave., New York, N. Y.

(314) OPEN-HEARTH SHEET STEEL—Booklet, 55 pages, revised information needed in the ordering of steel sheets, gives sheet weights, bundling tables, standard commercial tolerances, and trade customs and practices.—Inland Steel Company, Chicago, Ill.

(315) FIRST-AID — Catalog FA-2, 35 pages, a complete list and price data of first-aid and safety appliances now available.—Mine Safety Appliances Company, Pittsburgh, Pa.

(316) SWITCHGEAR—Bulletin GEA1389, 4 pages, describes and illustrates the circuit-breaker oil-blast explosion chamber. —General Electric Company, Schenectady, N. Y.

(317) LIGHTNING ARRESTERS — Bulletin 10, of a series, gives "theory, fact, and experience" in lightning arrester design, illustrated. — Electric Service Supplies Company, 17th and Cambria Sts., Philadelphia, Pa.

(318) GEARS—Catalog, 28 pages, "Celoron" silent gears. Design, construction, and rating tables.—Continental-Diamond Fibre Company, Newark, Del.

(319) POWER PLANT SPECIALTIES—Catalog 400. Valves, gages, lubricating devices, and other power plant accessories. —The J. E. Lonergan Company, 211 Race St., Philadelphia, Pa.

(320) PUBLICATION—Volume I, No. 1 of "The New Houghton Line," a revival. —E. F. Houghton & Company, Third, American and Somerset Sts., Philadelphia, Pa.

(321) LATHES—Catalog 92, 128 pages, illustrations, descriptions, and prices of the South Bend Series "O" line of lathes from 9 to 18 in.—South Bend Lathe Works, 426 E. Madison St., South Bend, Ind.

(322) BALL AND ROLLER BEARINGS—Manual 11, the complete line of ball and roller, thrust and radial bearings.—Bantam Ball Bearing Company, South Bend, Ind.

(323) FURNACES—Bulletin O-3H, R-S oil-fired, pot-type furnaces, using round or rectangular pots, types A and B.—Ryan, Scully & Company, 3711 Wissahickon Ave., Philadelphia, Pa.

(324) CONTROLS—Loose-leaf catalog on the various controls for gases and liquids. —The Shallcross Control System Company, Milwaukee, Wis.

(325) SPEED REDUCERS—Bulletin 53, herringbone-Maag speed reducers for small motor drives.—The W. A. Jones Foundry & Machine Company, 4401 Roosevelt Road, Chicago, Ill.

(326) WELDERS—Bulletin, 50-ton projection welder designed and built for one of the largest automobile wheel manufacturers.—The Thomson-Gibb Electric Welding Company, Lynn, Mass.

(327) STEEL — Booklet, "Patent Air-Hardening Cobalt-Chromium Steel Brand-Cobaltcrom PRK 33."—Darwin & Milner, 1258 West 4th St., Cleveland, Ohio.

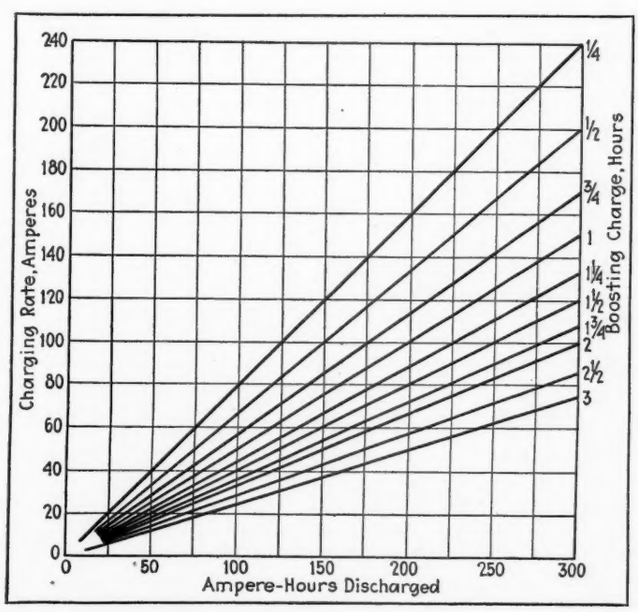
MAINTENANCE ENGINEERING'S DATA SHEETS

LEAD STORAGE BATTERIES

STORAGE batteries of the lead-acid type consist of alternating positive and negative plates immersed in a dilute solution of sulphuric acid made by pouring the pure acid into distilled water. The active material of the positive or brown plate is composed of lead peroxide contained within a supporting structure usually made of lead-antimony alloy. Negative plates are gray in color and consist mostly of spongy metallic lead.

A group of positive and a group of negative plates meshed together with their separators form an Element, and when immersed in the electrolyte constitute a Cell. In practice two or more cells are connected permanently together to form a Battery.

Charging—Only direct current can be used for charging storage batteries. If the supply is alternating current it must be converted to direct current by an m.g. set, synchronous converter, or rectifier.



Locate on the bottom line the number of ampere-hours discharged from the battery; then trace upward to the point of intersection with the diagonal line representing the time available for the boosting charge. The safe charging rate in amperes may be read by tracing left to Charging Rate, Amperes.

Regulation of the current value, so that the battery will be charged at the proper rate, is highly important. Two general systems, with modifications, are in use: (1) Constant-Current method, or its modification, the Step method. (2) The Constant-Potential method.

In the first method the current is kept at a constant value by cutting out resistance with a rheostat, thus increasing the voltage impressed on the battery as its voltage increases. The normal current flow is maintained until all of the cells are gassing freely; then it is reduced to approximately 40 per cent of the initial rate and held at this value until charging is completed, or free gassing again takes place.

In the so-called Step method, charging is started at a high rate. When the cell voltage reaches 2.35 volts the current is reduced and held at the new value until the voltage again reaches 2.35 volts per cell, whereupon it is again reduced, and so on until the finishing rate is reached.

In the Constant-Potential method, the initial charging rate is high but, as the battery voltage rises, the charging current is reduced automatically by the rising battery voltage, eventually reaching a low value.

A modification of the Constant-Potential method involves the use of a fixed resistance of small value in series with the battery. A d.c. generator with a suitable drooping voltage characteristic also may be used for individual charging circuits. With this method the initial charging rate is limited to some desired value, and the charging current is reduced gradually as the battery voltage rises. The current and charging bus voltage values used are determined by local conditions, mainly governed by the time available for charging.

In some services the capacity of a battery may be insufficient for a full day's work and a "boosting" charge may be necessary. The rate that can be employed safely depends on the ampere-hours discharged from the battery and the time available for the boosting charge. With these factors known, the maximum charging rate can be determined from the accompanying chart. Generally speaking, any rate may be used safely that will not cause excessive gassing or rapid increase in temperature.

While charging it is important to avoid:

(Continued on the following page)

MAINTENANCE ENGINEERING'S DATA SHEETS

Lead Storage Batteries

(Continued from the preceding page)

1. Excessive gassing. This action tends to loosen active material on the plates, thus shortening their life.

2. Cell temperature in excess of 115 deg. F. Overheating promotes deterioration of the separators between the plates and corrosion of the grids.

3. In general, it is not advisable in routine charging to replace more than 110 to 115 per cent of the ampere-hours discharged.

Inspection and Maintenance—For efficient service and maximum life of lead storage batteries, it is important that:

1. Level of electrolyte be kept above top of separators. Loss of electrolyte represents mostly water that has evaporated or been decomposed during charging. To restore level of electrolyte add distilled water. Do not add acid.

2. Determine specific gravity of electrolyte in a few "pilot" cells at frequent intervals. The gravity of a fully charged battery should be 1.210 to 1.275 at 80 deg. F., depending upon the type and service of the battery. The gravity falls as the battery is discharged, reaching a minimum of 1.140 to 1.180 at complete discharge, depending upon the service. Specific gravity can be checked most conveniently by means of a hydrometer. If water is necessary it should be added after the hydrometer readings are taken.

Generally speaking, stationary batteries usually use the lower specific gravities as their volume of electrolyte is greater, whereas batteries in smaller containers, such as rubber jars, for automotive purposes, have such a small amount of electrolyte that it is necessary to use the higher specific gravities in order to obtain capacity.

Several times a year, take and record gravity and occasionally voltage readings for each cell of batteries in daily use, such as industrial tractor and truck service. Voltage readings must be taken while the battery is being charged or discharged. Such records are valuable aids in promptly detecting abnormal conditions. For batteries in other classes of service, the frequency of taking readings will vary greatly with the service; therefore, definite instructions should be obtained from the battery manufacturer in all cases.

3. Batteries in hard daily service should be given an equalizing charge once a week. After the normal charge, continue charging at or below the finishing rate until the electrolyte in all cells reaches its maximum gravity. Three successive readings of gravity, or voltage and current, taken at one-hour intervals should show no increase or change before the charging is discontinued. If the specific gravity of any cell or cells is materially less than the normal standard specific gravity it is a sign that the cause should be investigated and removed.

Possible causes of low specific gravity of electrolyte are: Short circuit; loss of acid caused by leak in container or seal; overflushing; or stopped vent plug. If trouble is due to short circuit, remove short and give special charge. *Do not add any acid* unless the trouble is definitely known to be due to loss of acid. Add acid only when replacing water lost by evaporation. Use sulphuric acid of not more than 1.300 specific gravity and stop adding it as soon as the specific gravity of the electrolyte has reached its normal value for the type of battery in question.

Do not use metal containers for acid or electrolyte.

If the gravity of a cell is more than 1.275, replace enough of the electrolyte with distilled water to bring the gravity down to the proper value.

After the addition of either water or acid, the equalizing charge should be continued, to insure thorough mixing, until several hydrometer readings taken at 15-min. intervals are constant.

4. Battery must be kept clean; all closed-top or sealed batteries usually may be washed off with clear water—hot or cold. Do not place tools or metal objects on top of cells. Acid or electrolyte on cells may be neutralized by ammonia water or a solution of bicarbonate of soda (baking soda). Keep terminals well greased with vaseline. Occasionally wiping positive terminal with a rag moistened with ammonia or soda, followed by clear water, and then coating with vaseline will prevent corrosion. Inspect a battery frequently to detect cracked jars, broken or loose terminals or connections, and other defects. When found, they should be remedied at once.

5. Avoid discharging a battery completely. If unavoidable, charge again at once. Allowing a battery to remain discharged is injurious to the plates and greatly increases the risk of freezing.

Note: *It has been recommended previously that only distilled water be used. This is the safest procedure, but it is not always absolutely necessary with lead batteries. However, before using a city or local water, it is highly advisable to submit a quart sample to the battery manufacturer for analysis and advice as to whether the water is safe to use in a battery.*